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Estimation of Total Chinook Mortality Associated with Seine Fishing in Johnstone Strait, Sabine Channel, and Juan de Fuca Strait During 1987

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ESTIMATION OF TOTAL CHINOOK MORTALITY ASSOCIATED WITH SEINE FISHING IN JOHNSTONE STRAIT, SABINE CHANNEL, AND JUAN DE FUCA STRAIT DURING 1987

by

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ABSTRACT

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In 1987 the Biological Sciences Branch, Department of Fisheries and Oceans, conducted a study in the Johnstone Strait, Sabine Channel, and Juan de Fuca sockeye seine fishery to assess total chinook mortality. The catch statistics presently recorded by the Department of Fisheries and Oceans are determined from records of chinook sales and are suspected to underestimate the catch of large chinook (>2.3 kg. round wt.) and to seriously underestimate the total mortality of small chinook. Data were collected for catch per seine set for each salmon species and for three size categories of chinook, the number and location of sets made by vessels per day, and the total number of vessels per day active in the fishery. Calculation of total catch involved extrapolating the estimated mean catch per set over all sets made and incorporated the Monte-Carlo bootstrap technique to determine the variance about the mean catch estimate. Total chinook mortality in the Johnstone Strait sockeye fishery was estimated to be 19,833 of which 5,716 were juveniles, 2,098 jacks, and 12,019 adults. Commercial records of sales for the 1987 season indicate a catch of 2,959 jack chinook and 10,398 adults. Total chinook mortality in the Juan de Fuca fishery was estimated to be 9,428 of which 3,297 were juveniles, 842 jacks, and 5,289 adult chinook. Commercial sales slip data for 1987 recorded 3,413 jacks and 5,263 adults. The ratio of estimated catch to reported catch for chinook under 2.3 kg (5 lb) in Johnstone Strait was 2.7 and for Juan de Fuca was 1.2.

RÉSUMÉ

Nagtegaal, D. A., P. J. Starr and B. Riddell. 1990. Estimation of total chinook mortality associated with seine fishing in Johnstone Strait, Sabine Channel, and Juan de Fuca Strait during 1987. Can. MS Rep. Fish. Aquat. Sci. 2062: 91 p.

En 1987, le personnel de la Direction des sciences biologiques du ministère des Pêches et des Océans a réalisé des études dans les zones de pêche à la senne du saumon rouge dans le détroit Johnstone, le chenal Sabine et le détroit Juan de Fuca, afin d'évaluer la mortalité totale des saumons quinnats. Les statistiques sur les captures dont dispose actuellement Pêches et Océans proviennent des registres de vente de saumons quinnats, et l'on soupçonne qu'elles sous-estimer les captures de gros spécimens de cette espèce (dont le poids brut est supérieur à 2,3 kg) et sous-estiment de beaucoup la mortalité totale des petits quinnats. On a relevé les captures par coup de senne de chaque espèce de saumon et pour trois catégories de taille de saumons quinnats, le nombre de coups de senne effectués par bateau par jour et leur emplacement et le nombre total de bateaux en service dans les zones de pêche par jour. On a calculé les captures globales pour la totalité des coups de senne, par extrapolation des captures moyennes estimatives par coup, et on s'est servi de la méthode d'échantillonnage (bootstrap) Monte Carlo afin de déterminer la variance de l'estimation des captures moyennes. Dans les zones de pêche des saumons rouges du détroit Johnstone, la mortalité totale des saumons quinnats a été estimée à 19 833 spécimens, dont 5 716 juvéniles, 2 098 mâles ayant atteint précocement la maturité et 12 019 adultes. Les registres commerciaux des ventes révèlent que, pour la saison de 1987, les pêcheurs ont capturé 2 959 saumons quinnats mâles ayant atteint précocement le maturité et 10 398 adultes de cette espèce. Dans la pêcherie du détroit Juan de Fuca, la mortalité totale de saumons quinnats a été estimée à 9 428, dont 3 297 juvéniles, 842 males ayant atteint précocement la maturité et 5 289 adultes. En 1987, d'après les bordereaux de vente, 3 413 saumons ayant atteint précocement la maturité et 5 263 adultes auraient été capturés. Le rapport entre les captures estimatives et les captures signalées de saumons quinnats de moins de 2,3 kg (5 livres) était de 2:7 dans le détroit Johnstone et de 1:2 dans le détroit Juan de Fuca.

INTRODUCTION

In 1985 a treaty concerning management of Pacific salmon between the governments of the United States and Canada was instituted. One commitment of the treaty was the recording of all sources of mortalities for chinook including landed catches and non-accounted mortalities during fishing.

Landed catch is recorded by the Department of Fisheries and Oceans by accumulating sales slips which record the sale of fish from fishermen to the primary processor. These documents record the location of catch by statistical area, the gear type used, the category of fish sold (species and grade) and the associated weight. The number of pieces sold is not routinely recorded. Chinook sold by seine fishermen should exceed or equal the 1.4 kg (3 lbs) (round weight) minimum size limit. Sub-legal sized chinook in seine catches [less than 45 cm, or less than 1.4 kg (3 lbs) round weight] are either discarded by fishermen or sold as other salmon species. Small chinook salmon, usually between 1.4-2.3 kg (3-5 lb) round weight, are traditionally sold by the piece (not by weight).

Since the inception of biological catch sampling programs (in the late 1960s), it has been hypothesized that the total catch of chinook in seine fisheries is under-reported, particularly for small chinook (under 5 lb round weight). This is based on the fact that the sampled catch frequently exceeds 50% of the reported catch (and occasionally even 100%), even though the sampling goals (based on vessel numbers) are nearer to 20% of the catch. This potential shortfall in reported catch has led to controversy in the fishing industry as to the magnitude of the mortality of chinook salmon in seine fisheries. Various user groups have claimed that the actual catch is anywhere from 1 1/2 to over 10 times the reported catch. In the context of the Pacific Salmon Treaty, it is important to accurately know the magnitude of the chinook mortality in order to determine the productivity of chinook salmon. In addition, obtaining accurate estimates of total chinook catch in the seine fisheries is crucial to providing unbiased expansion factors for estimating total recoveries of coded wire tags (CWT) used to evaluate hatchery production and management actions.

To evaluate the impact of seine fisheries on chinook, the Biological Sciences Branch, Department of Fisheries and Oceans, undertook an independent estimation of total chinook catch to more accurately determine total fishing mortality. This estimate would be used as a comparison with the recorded sales slip data as well as to investigate the catch of sublegal sized chinook.

In 1986 a pilot study was conducted in Johnstone Strait to assess the logistics of independently estimating chinook

mortality (Nagtegaal et al. 1988). Johnstone Strait was chosen as the pilot study area since controversy existed concerning the magnitude of chinook catch in this area. However, historical catch records indicate that seine fisheries in Juan de Fuca also catch significant numbers of small chinook. As a result, the 1987 study was conducted in Juan de Fuca, Johnstone Strait and Sabine Channel in the Strait of Georgia.

The Ministry of Environment conducted a similar but somewhat downsized version of this study for the fall chum fishery in Johnstone Strait. In addition, the Ministry of Environment monitored a special one day coho fishery in Juan de Fuca.

The purpose of this report is to present the methodology and results of the chinook mortality studies conducted during the 1987 sockeye and pink fisheries, and the later chum fisheries.

METHODS

A. GENERAL METHODOLOGY

Three main items of information are needed for this program: 1) catch per seine set by species and size categories, ii) number of sets made in a time/area stratum per vessel, and iii) the numbers of vessels fishing by time and area stratum. The overall concept of the program was to extrapolate the estimated mean catch per seine set over all sets made.

Table 1 lists the dates of the survey and the dates during 1987 that Johnstone Strait, Sabine Channel, and Juan de Fuca were open to the commercial seine fleet.

i) Catch/set:

Data for the catch of individual sets were collected by observers boarding seine vessels as the set was being brought on board. The procedure involved approaching the vessel and requesting permission from the skipper to board, recording the catch of all species, and taking biological samples whenever possible. Observers could quite easily stand beside the drum on the stern of the vessel and observe the catch. Most fish were funnelled to the end of the net and were brought on deck over the stern. Undersized fish, including juvenile chinook would

sometimes be tangled or gilled in the web and rolled up on the drum as the net was being hauled. Observation was more difficult when large catches were encountered. Portions of larger catches often were lifted directly into the vessel hold using a brailer until all the catch was in the hold.

Chinook catch is divided into three size categories: i) adults [>2.3 kg (5 lb), >57 cm fork length]; ii) jacks {1.4 kg-2.3 kg (3-5 lb), 45-57 cm]; and iii) juveniles [<1.4 kg (3 lb), <45 cm]. In all sets, the numbers of chinook caught were counted by the observers. Observers counted the numbers of all other species caught when the catch was less than approximately 50 fish, and for large catches, numbers were estimated by either the observer or the skipper. Other pertinent data such as location, tide, time of day and type of set (tied to shore vs. open sets) were also recorded.

ii) Biological sampling:

Biological data (length/sex/maturity/scale) were collected (MacLellan 1987) from most fish in the jack and juvenile categories. Some adult chinook were also sampled. Sampling was limited by availability and cooperation of seine boat skippers. Adult samples were limited because skippers were worried that the fish would be mutilated and consequently lose commercial value.

iii) Number of sets/day/vessel:

The observers would ask the skipper of each vessel boarded for the number of sets made up until the time of boarding. From these data an average number of sets per hour could be calculated per stratum. The total number of sets made that day was determined by extrapolating the calculated average number of sets per hour over the total time available for fishing in that day. Available fishing time was defined on the basis of the official opening/closing times issued by the Department of Fisheries and Oceans, Fisheries Branch, or assumed to be from dawn to dusk.

iv) Gear count:

Prior to each week's fishery opening, a routine Departmental overflight was scheduled by the Department of Fisheries and Oceans, Fisheries Branch. When the fishery was scheduled to last more than one 24-hour period, an extra gear count was to be taken for each additional fishing day during a given week. Usually during each week, fishery officers also

estimated the number of vessels on the fishing grounds from their patrol vessel.

v) Cannery data:

As part of the coastwide sampling for recovery of coded-wire tags, standard biological samples were collected by J. O. Thomas and Associates at the major cannery facilities in Vancouver. These data were collected during the sockeye and pink seine fisheries in Johnstone Strait and Juan de Fuca and could be used to corroborate the field biological data collected from this survey.

vi) Catch estimation and Monte-Carlo simulations of confidence regions:

Total catch for each species and/or size stratum was calculated according to the following equation:

$$T_{lj} = \sum_{k=1}^{m} \sum_{i=1}^{n} (\bar{C}_{ijkl} * \bar{S}_{ik} * V_{ik}) \qquad \text{(equation 1.1)}$$

where

T_{lj} is the total catch estimate for size category j of species l over the season

$\bar{C}_{ijkl}$ is the average catch/set by fishing day k and geographic area i for category j of species l

$\bar{S}$ is the average number of sets/day/vessel within each (i, k) stratum

V_{ik} is the estimated total number of vessels per (i, k) stratum

m is the number of days
n is the number of areas

The Monte-Carlo simulation technique (Efron 1982) involves resampling with replacement the data for catch/set, sets/day/vessel and numbers of vessels per day within each time and area stratum, and determining the average of these resampled data prior to each calculation of total catch. This process of calculating a mean value for each variable by day and estimating the total catch was repeated 1000 times. The final estimate of total catch by day or season was determined to be the mean of these 1000 iterations. Confidence regions about the average catch estimate were determined by excluding the upper and lower 2.5% of the distribution of catches resulting from the 1000 iterations.

If sufficient data had been collected on a given day, the data for catch/set and sets/day/vessel were resampled with replacement the same number of times as the number of data points collected for that variable on that day. Using a random number generator (subroutine GGUBFS of IMSL 1980), data points were selected from the data array for that variable. The mean was then calculated for each variable and incorporated into the equation to calculate total catch.

Since the daily gear counts are only a point estimate, the data could not be resampled in the manner described above. In 1986, an approximate estimate of the error in the overflight counts was made by looking at the variation in gear counts for Johnstone Strait between consecutive days within a fishing week. Assuming that no vessel movement in or out of Johnstone Strait occurred in a given fishing week, the changes in total gear count could be attributed to counting error. The coefficient of variation ranged from 6-16% based on weeks 3 and 4 of that fishery (Nagtegaal et al., 1988). Although the assumption of no movement is probably unrealistic, the results are at least an approximation of the level of error. A similar calculation was not possible with the 1987 data due to the lack of second overflights within fishing weeks. Based on the 1986 results, the coefficient of variation for overflight counts was set at 10%. This was incorporated into the calculation of catch by using a random normal deviate procedure (Subroutine GGNML of IMSL 1980) to include the error as follows:

$$\text{Standard Deviation (S)} = (10\% \text{ error} * \text{gear count})/100 \qquad \text{(equation 1.2)}$$

and

$$Y(I) = (RND(I) * S) + M \qquad \text{(equation 1.3)}$$

Where the new value Y is equal to the product of the random normal deviate (RND) and the standard deviation (S) added to the mean (M), in this case the original point estimate. This value then served as the resampled estimate of gear and was used in the next calculation of total catch in the Monte Carlo simulation.

B. MISSING DATA

Due to equipment failures and inclement weather it was impossible to collect data for every stratum. Missing data cells were extrapolated according to the following procedures.

i) Catch per set:

A cell was considered empty if fewer than 5 sets were observed in that day and study area. If the total number of sets observed during that fishing week was greater than 5, then the average catch/set calculated for all days in that week within the study area was assumed to be the value for that day. If the total number of sets observed for that week was less than 5, then the average catch per set calculated for the following week in that study area was assumed to be the value for that day. Justification for this method comes from an analysis of variance of catch per set by day (Tables 2-4). In virtually all cases, the variance within a given day was greater than among days. Therefore, it would be reasonable to use the mean for the entire week if a daily stratum was empty.

ii) Sets per day per vessel:

As described earlier, data for sets per day were collected each time a vessel was boarded. Estimates of total sets per day were made by extrapolating the average number of sets per hour over the available time for fishing in that day. Table 5 contains the opening times and total available hours for fishing by statistical area and date that were used in this analysis. If less than five observations for sets per hour were collected, then all information for that week in a given area was pooled to calculate the average number of sets per hour for the week. This estimate was then used to calculate the total numbers of sets made for that day.

iii) Gear counts:

Missing data by day were estimated to be the average daily number of vessels counted during that fishing week within the stratum if data for more than one day was available during a given week. If only one overflight gear count was taken for a given week then that gear count was applied to each day of that week. These counts were compared with the number of observer boardings made in that area on that day and if the number of unique boardings was greater than the overflight count, the boarding data were assumed to be the better estimate. On some days the Fishery officers would also estimate the gear on the fishing grounds. When available we considered the overflight data to be the best estimate of the total gear count.

C. DATA COLLECTION

i) Johnstone Strait:

Collection of data in Johnstone Strait was stratified by day and five sub areas (Fig. 1). Data were collected by day since this was the lowest level of time stratification possible given available resources. Johnstone Strait was split into five sub areas corresponding to the management stratification presently used and to areas of major traditional fishing effort. The field staff for this study in Johnstone Strait consisted of five teams (one boat driver/one biological observer), one for each sub-area. One set of observers was stationed in Port Hardy to monitor the Gordon Group area. Two sets of observers were stationed in Port McNeil to cover the North Shore area of Malcolm Island and the Upper Johnstone Strait area to Robson Bight. Two sets of observers were stationed at Kelsey Bay. The first group monitored the area above Kelsey Bay to Robson Bight and the second group covered the areas below Kelsey Bay to Discovery Passage.

One adjustment relative to the 1986 pilot study was made concerning the groupings of Johnstone Strait sub-areas in the calculations. From the pilot study in 1986, it was noted that the majority of fishing effort was concentrated in the Upper Johnstone Strait sub-area and that few vessels fished in Discovery Passage. From these observations, it was decided in 1987 to move the observer team that had been located in Discovery Passage in 1986 to Kelsey Bay in order to increase coverage of the area in Upper Johnstone Strait. As a result of this move, however, few vessels were monitored in the Discovery Passage area. To compensate for this, it was decided to use catch per set and sets per day data from the Lower Johnstone Strait sub-area to calculate catch estimates for Discovery Passage. Comparison of 1986 sockeye catch per set data between Lower Johnstone Strait and Discovery Passage data (Table 6) indicates that less than 10% of the variance was attributed to area differences.

ii) Sabine Channel:

Sabine Channel (Fig. 2) data were collected on August 16 and 17 only. It was only possible to relocate sampling crews to this fishery when Juan de Fuca was closed to fishing, since resources were limited.

iii) Juan de Fuca Strait:

Collection of data in Juan de Fuca was stratified as much as possible by fishing line. Seine vessels align themselves along imaginary fishing lines perpendicular to the coast from the western border of statistical area 20 (Blue Line) to Sheringham Point (Fig. 3). Seiners vie for position along these fishing lines, and during intense fishing periods, several vessels will queue in a lineup to make a set at a particular spot. The majority of fishing effort was concentrated in the first three lines. Initially, two teams of observers (one driver/two biological observers) were stationed in Port Renfrew. Since seine vessels were concentrated in a small area, it was felt that increased sampling could be achieved by having two observers per team. In that way, each team could conceivably monitor twice as many boats. Power skiffs are used in the Juan de Fuca Fishery to maintain the position of the seiner while the set is towed and then hauled aboard. The use of these power skiffs made it very difficult for the biological observer to be placed on board while the net was hauled in. This situation demanded that the observer had to be placed aboard before hauling began; consequently the person would remain on the seiner for approximately one hour to monitor one set. It became evident that it was impractical for the driver to place each of the two observers on separate vessels and then keep track of them at all times. After the first week therefore, each team placed observers on only one vessel at a time.

Stratification by fishery line was accomplished by somewhat arbitrarily grouping lines 1-3 and 4-12. This combination was based on the results that the average sockeye catch per set was considerably higher in the first three fishery lines compared to subsequent lines. A more detailed stratification by fishing line may have been desirable but, since data were limited, it was decided to minimize the groupings. Stratification by fishing line was applied to the first two openings of the fishery only, since insufficient catch per set and gear count data were available for the September 2 opening. We treated the September 2 fishery as a single stratum.

RESULTS

A. JOHNSTONE STRAIT

A total of 569 observer boardings were made during the five weeks of the sockeye and pink seine fishery from August 2 - September 2, 1987. There were 250 adult chinook, 47 jacks, and 150 juveniles recorded by the observers. A total of 248 different vessels were boarded during this time. During the chum fishery in Johnstone Strait 77 boardings were made. A total of 13 adult, 1 jack, and 2 juvenile chinook were recorded.

Coverage of the Upper Johnstone Strait sub-area was better than in 1986 because the observer team from Discovery Passage was moved to Kelsey Bay. Placement of two teams of observers in Kelsey Bay did, however, create some new difficulties, primarily due to adverse weather conditions experienced in this area. Table 7 summarizes the boardings made by sub-area.

i) Catch per set:

Catch per set for juvenile chinook ranged from 0 to 6, for jacks from 0 to 4, and for adults from 0 to 12 (Table 8). The overall mean catch per set during the sockeye and pink fishery was 0.44 for adult chinook, 0.08 for jacks, and 0.26 for juveniles. Mean catch per set for juveniles and adult chinook was highest in the North Shore sub-area. Highest catch per set for jacks was recorded in the Gordon Group sub-area. Catch of sockeye per set was similar between sub-areas except that the Gordon Group was lower on average.

Distribution of catch per set was highly skewed to low rates of catch per set (Fig. 4-7). The proportion of null sets observed for juvenile chinook was 87%, for jacks was 95%, and for adults was 82%. The proportion of null sets for sockeye was 35%, but in approximately 55% of the sets made 10 or less sockeye were caught.

A two factor analysis of variance was used to examine the effect of area and time (week) on catch per set for adult, jack and juvenile chinook (Table 9). We note that there was no significant effect of area or week on jack catch per set but there was a significant effect of area, week and area/week interaction on juvenile catch per set. A declining trend in juvenile catch per set during the season was evident in almost all areas. Considerably higher juvenile catch rates were recorded in the northern sub-areas in Johnstone strait. For

adults, only area/week interaction was significant, but no clear trends were evident. Catch per set for sockeye decreased over time in all sub-areas. It should be noted that area and week accounted for very little of the total variance in catch per set (1%-6%) for chinook and sockeye.

Mean chinook catch per set was compared to the type of set (open or beach) by sub-area in Johnstone Strait (Table 10). In virtually all cases, chinook catch per set was higher for beach sets than for open sets in the Gordon Group, Upper Johnstone Strait, and Lower Johnstone Strait sub-areas. No comparison could be made in the Discovery Pass sub-area due to limited data, and in the North Shore sub-area since few beach sets were made.

ii) Biological sampling:

A total of 76 juvenile, 23 jack and 33 adult chinook were sampled for length/sex/maturity/scale data (Table 11). Biological data collected from the cannery are listed in Table 12. Sampled fish were assigned to the appropriate category (adult, jack, juvenile) on the basis of length (length/weight relationship from Argue et al. 1967). The cutoff point for adults was >57 cm, for jacks was 43 to 57 cm and for juveniles was <43 cm. A summary of age data for Johnstone Strait samples is contained in Table 13.

Although sample sizes for both cannery and survey data were small, modal length, mean length and percent maturity were similar for males in the jack and juvenile chinook category. No comparison could be made between females. Length frequencies for juveniles and jacks combined were converted to cumulative percent frequencies and compared using a Kolmogorov-Smirnov two sample test (Zar 1984). No significant differences were detected ($D_{obs} < D_{alpha}$) between cannery and survey data. If fishermen discarded considerable numbers of juvenile chinook prior to the sale of their catch, one might expect to find chinook <3 lb (45 cm) absent from the cannery data and present in the survey data. Nagtegaal et al. (1988) concluded that the lack of any significant differences indicate that either discarding is unbiased for fish less than 57 cm or that very few were discarded.

iii) Number of sets/day/vessel:

The average number of sets per day ranged from 2.6 to 19.4 depending on the length of day and area (Table 14). Data were collected each time a boarding was made and the type of set recorded but no estimate was made to determine what proportion of the effort for that day was expended on open or beach sets. The

number of sets made in a given day depends on the fishing strategy. Seiners decide whether it is more worthwhile to wait in a lineup to make a set, in a presumably more productive spot, or to make more sets in less productive areas where no lineups exist (Ledbetter 1986). The geography of the area and traditional fishing patterns also play a key role in determining what proportion of beach or open sets made. From Table 10 we note that a variety of combinations of open and beach set strategies exist between sub-areas in Johnstone Strait.

iv) Gear count:

The number of seiners that fished in Johnstone Strait ranged from 172 to 350 (Table 15 and 16). Within sub-areas the gear count varied considerably from week to week. For August 10 a surface gear count was recorded by fishery officers on the fishing grounds. The gear count compared favourably with overflight data for this week indicating that no major change in effort occurred between days during this fishing week. Vessel count was consistently highest in the Upper Johnstone Strait sub-area during the entire sockeye fishery.

v) Total catch estimate:

Total catch estimates from our sampling program, in both the sockeye and chum fisheries, exceeded the reported catch from the sales slips by 15% for adults, 29% for juveniles plus jacks, and 20% for sockeye (Table 17). Total sales slip catch estimates lie within the confidence range of the bootstrap estimates, but when data were examined by week we note some discrepancies. Even though the bootstrap estimates were not always comparable to the sales slip data on a weekly basis, no trend in over or underestimation of adult chinook or sockeye catches was evident. The bootstrap estimates for jack chinook consistently underestimated the sales slip data and for the Aug. 2-3 and Sept. 1-2 periods and the sales slip estimate was outside of our range of confidence limits. The bootstrap estimates for adult chinook and sockeye were considerably higher than the sales slip estimates even when the data were compiled by statistical area, but our estimate for jacks only was considerably lower (Table 18). Bootstrap estimates were also compiled by sub-area within Johnstone Strait although no comparison with sales slip data was possible. The lower Johnstone Strait sub-area accounted for 29% of the adult chinook catch, 22% were taken in Upper Johnstone Strait, and 18% from the North Shore sub-area. For jack and juvenile chinook 41% were taken in the Gordon Group sub-area, 30% for North Shore, and 29% from the Upper Johnstone Strait sub-area. No comparison of the juvenile chinook catch estimate was possible with the sales slip catch estimates.

The bootstrap technique produces an essentially unbiased estimate of the associated variance of these catch estimates since no assumptions are made concerning the distributional attributes of the error of the variables. An examination of the minimum and maximum values of these estimates and a plot of their frequency distribution (Fig. 12-15) indicates that the catch distribution was skewed. This is not unexpected since the catch per set distribution was highly skewed.

B. SABINE CHANNEL

Since the Sabine Channel fishery was not large, we were able to board each vessel that fished in the area during the one week this fishery was monitored. During the August 16-17 opening, 30 boardings were made on 22 different seiners. A total of 5 adult, 1 jack, and 8 juvenile chinook were observed (Table 7).

i) Catch per set:

The overall mean catch per set during the August 16-17 opening was 0.17 for adults, 0.03 for jacks and 0.27 for juvenile chinook (Table 8). Similar catch rates were observed in Sabine Channel as in Johnstone Strait for this one opening.

When catch per set was compared to the type of set (Table 10) we note that for adult chinook and sockeye catch rates were highest for beach sets although not enough sets were observed to make any definite conclusions.

ii) Biological sampling:

Samples were taken from only 5 adults, 3 jacks, and 2 juvenile chinook. A summary of age data is contained in Table 13. Length frequencies were not analyzed due to limited data.

iii) Number of sets/day/vessel:

The number of sets per day ranged from 4.3 to 11.0 (Table 14). A combination of open and beach set strategy existed in this area and affected the number of sets made by each vessel.

iv) Gear count:

The number of seiners that fished in Sabine Channel during the sockeye fishery ranged from 14 to 43 (Tables 15 and 16). There were 43 seiners fishing during the opening that we were able to monitor. Since we were unable to monitor this area during the entire sockeye fishery, the peak week of fishing in this area was selected.

v) Total catch estimate:

A summary of total catch estimates using the bootstrap technique as well as sales slip information are listed in Table 17. The sales slip estimates for adult chinook and sockeye were within the confidence range of the bootstrap estimates, although our survey estimate for sockeye was 31% higher than the sales slip data. The sales slip estimate for jack chinook was 4 times greater than the bootstrap estimate. This in part maybe due to the fact that no jacks were observed on the second day (August 17) on the vessels that were boarded. Our survey estimate for jacks and juveniles combined was almost twice the sales slip estimate for jack chinook. One of the inherent problems in saleslip data is that catch from multiple areas may often be assigned to a single statistical area. Saleslip data from the Sabine channel fishery may be confounded with other areas because of the movement of seiners between this fishery and Johnstone Strait. No comparison of the juvenile catch estimate was possible with the sales slip catch estimates. Since data were limited no frequency distribution of catch estimates was plotted.

C. JUAN DE FUCA STRAIT

During the sockeye fishery 134 boardings were made on 90 different vessels. For the three openings of this fishery, 91 adult, 18 jack and 74 juvenile chinook were observed. For the one day coho fishery on September 27, 2 adults, 1 jack and 4 juvenile chinook were observed during 21 boardings (Table 7).

Due to the use of power skiffs in the Juan de Fuca fishery it was difficult to make many boardings in a given day. Even though the total number of boardings was not as high as desired, we did attempt to collect as much data as possible from all the fishing lines. It became evident that the only way to increase the number of boardings would be to increase the number of observer/driver teams.

i) Catch per set:

Catch per set ranged from 0 to 7 for adult chinook, from 0 to 3 for jacks and from 0 to 8 for juveniles (Table 8). The overall mean for adults was 0.68, for jacks was 0.13 and for juvenile chinook was 0.55. Catch per set for Juan de Fuca was also compiled by fishing line (Table 19). There was a decreasing trend in sockeye catch per set from the outer line (Blue line) towards Sheringham Point (line 12). This trend was not evident for chinook, but because sample size was small for the last lines monitored, the results are considered inconclusive. The strong relationship between sockeye catch rates and fishing line implied that some stratification by line would be important in our estimates of total catch.

Distribution of catch per set was highly skewed (Fig. 8-11). The proportion of null sets observed for juvenile chinook was 75%, for adults was 63%, and for jacks was 91%. The proportion of null sets for sockeye was 26% and 10 or less sockeye were caught in approximately 40% of the sets.

An analysis of variance was used to examine the effect of time (week) on catch per set for adult, jack and juvenile chinook and sockeye (Table 20). No significant effect of week on either jack or juvenile chinook catch per set was observed. There was a significant effect of week on adult chinook and sockeye but week only accounted for 1%-11% of the total variance in catch per set for chinook and sockeye.

Catch per set was also examined between different bottom depths. Average catch per set (by 10 fm intervals) indicated that the catch of adult and juvenile chinook tended to be higher in shallower water (Table 21). When data were grouped by 50 fm intervals the trend toward higher catch rates in shallower water was quite pronounced. No trend in sockeye catch was evident with respect to depth. The catch per set value for the 75-85 fm depth interval was considerably higher due to one large set. These results were considered preliminary due to limited samples from the shallow and deep contours.

ii) Biological sampling:

In Juan de Fuca Strait 18 juvenile, 28 jack and 60 adult chinook were sampled for length/sex/maturity/scale data (Table 22). Biological samples collected from the canneries in Vancouver are listed in Table 23. Sampled fish were assigned to the appropriate category (adult, jack, juvenile) as in Johnstone Strait. A summary of the age data is listed in Table 13. Size ranges and length modes were similar between cannery and survey samples for juvenile and jack chinook. Length frequencies for juveniles and jacks combined were compared as for Johnstone

Strait. The results of the tests and the conclusions were the same as for Johnstone Strait. The lack of any significant differences between survey and cannery data indicate that either discarding is unbiased with respect to length or that few juvenile chinook are discarded. It is presumed that these juveniles may be sold as other species (e.g. pink salmon).

iii) Number of sets/day/vessel:

The average number of sets per day ranged from 7.3 to 11.8 depending on the length of day and fishing strategy (Table 14). In Juan de Fuca, seiners choose to wait in lineups that usually exist in the first three presumably more productive fishing lines or make more sets in the less intense subsequent lines. Fishing effort is usually spread out over all fishing lines for the morning but by afternoon the effort tends to shift to the first few lines. The number of sets made in a given day was significantly affected by the strategy adopted.

iv) Gear count:

The number of seiners fishing in Juan de Fuca Strait ranged from 122 to 182 (Tables 16 and 24). Gear count for Juan de Fuca was collected by geographic landmark for the first two fishing periods but only a total count was available for the Sept. 1 opening. In order to keep the gear count comparable to the catch per set data each geographic landmark had to be assigned to a fishing line. Since no record of the fishing line number relative to the geographic location was kept, it was decided to separate the gear count on a larger scale. From Table 24 it was noted that higher catch per set values were recorded in the first three fishing lines. On this basis, it was decided to assign the first three fishing lines to the gear count for Bonilla Point and combine all data for subsequent lines with the geographic area from Owen Point to Sheringham Point. Overflight data were compared to the gear count derived from saleslip data (unique CFV licences landing catch), and no appreciable differences were noted (Table 16).

v) Total catch estimate:

Total catch estimates from our sampling program for the sockeye fisheries in Juan de Fuca exceeded the reported catch from sales slips by only 0.5% for adult chinook, 11% for sockeye, and by 25% for jacks and juveniles combined (Table 25). Our sampling program did not as accurately estimate the total catches in the September 27th coho fishery. The sales slip estimates lie within the confidence range of the bootstrap estimates except for jack chinook. The weekly as well as total estimates for jack

chinook were substantially different from the sales slip data. When data were examined by week, both sockeye and adult chinook bootstrap estimates compared favourably with the weekly breakdown of the sales slip data. No comparison of juvenile chinook catch estimates was possible with the sales slip catch information.

An examination of the minimum and maximum values of the catch estimates and a plot of their frequency distribution (Figs. 16-19) indicates that the catch distribution was skewed. This is not unexpected since the catch per set distribution was highly skewed.

DISCUSSION

A. GENERAL

Nagtegaal et al. (1988) suggested that the jack category in the sales slip data accounts for only a portion of the combined catch of jack and juvenile chinook from the survey area. The results from the 1987 Juan de Fuca and Johnstone Strait surveys support this hypothesis since no differences in length frequencies were detected between the samples of "jacks" at the canneries and the combined samples of "jacks" and juveniles observed in these surveys. On this basis, the best estimate of unreported chinook catch is the comparison of jack catch from the sales slip data and the jack and juvenile combined catch from the survey data. In 1987 the catch in Johnstone Strait of chinook less than 2.3 kg (5 lb) was 2.6 times (95% confidence limit: 1.7-3.8) greater than the amount recorded in the sales slip data. For Juan de Fuca, the catch was estimated to be 1.2 times (95% confidence limit: 1.0-1.8) greater. The expansion factor for Johnstone Strait was less than half the value recorded in 1986 (Nagtegaal et al. 1988).

A cursory look at the incidental catch of chinook in the Sabine Channel sockeye fishery revealed that chinook catch rates were comparable to those observed in Johnstone Strait. The incidental catch of chinook in the Johnstone Strait chum fishery was considerably less than during the sockeye and pink fishery. Since only a one day fishery was observed in these areas the results are considered inconclusive. No expansion factor was estimated.

Depending on the true fate of these small chinook, the expansion factor may be quite variable from year to year. Table 26 lists the catch of chinook and sockeye from 1975-1987. In

Johnstone Strait there has been a decreasing trend in jack chinook catch although no major difference between 1986 and 1987 was recorded. The catch for jack chinook in Juan de Fuca this year was only one tenth of that recorded in 1986. This significant decrease in catch may have a considerable effect on the expansion factor and therefore the present value of 1.2 may not be indicative of the situation in previous years. It is possible that, in years of higher abundance, small chinook are more readily discarded at sea than when few are caught per set.

The difference in expansion factors between Johnstone Strait and Juan de Fuca may in part be explained by the difference in processing. The majority of fish caught in Johnstone Strait are initially sold to a packer and then delivered to the cannery, whereas the fish that are caught in Juan de Fuca are usually delivered directly to the cannery by each seine vessel. The fate of the unreported chinook is unclear. Comparison of biological samples from the cannery and the survey suggest that most fishermen do not bother to discard juvenile chinook or sort their catch; at least when the average catch rate of juvenile chinook is less than one per set as it has been in 1986 and 1987. If the majority of small chinook landed reach the processor, it is not clear what criteria are used to determine whether these chinook are recorded as chinook on a sales slip or as other species, or at all. The additional step in processing in Johnstone Strait may have an effect on the overall outcome of how these small chinook are recorded compared to Juan de Fuca.

To determine the proportion of mature males in the jack and juvenile categories, both the sex ratio and percent maturity values from the biological sampling survey data were applied to the total bootstrap estimates. Application of the values for Johnstone Strait yielded a total of 1,876 mature males and 271 mature females (jack and juveniles combined). For Juan de Fuca 460 mature males and no mature females were recorded. Subtracting these values from the total catch estimates yielded 5,667 chinook (jacks and juveniles combined) from Johnstone Strait and 3,679 chinook from Juan de Fuca, representing the numbers of fish that could have contributed to future reproductive effort. Caution should be exercised with these results since biological samples from both Johnstone Strait and Juan de Fuca were of limited sample sizes. In addition, a large proportion of the juvenile chinook samples from Johnstone Strait were unsexed.

To put the catch estimates of this study in perspective relative to the total fishing effort in Johnstone Strait (Table 27), the survey was conducted when >98% of the chinook, sockeye, and pink salmon were caught. Similarly, the survey in Juan de Fuca was conducted when >93% of the chinook, sockeye, and pink salmon were taken in 1987.

The ratio of total chinook to sockeye catch for Johnstone Strait was 1:55 and for Juan de Fuca was 1:42. The ratio of juvenile to adult chinook for Johnstone Strait was approximately 1:1.5 and for Juan de Fuca was 1:1.3.

This study provides us with an independent estimate of the magnitude of the total chinook mortality during the Johnstone Strait and Juan de Fuca sockeye seine fisheries. More years of study will be required to assess changes in mortality rates due to differences in fishing effort for and abundance of sockeye, and their relation to chinook stock size.

B. SURVEY STRATEGY

To determine the sensitivity of the bootstrap technique to different levels of stratification we compiled the mean catch per set data by week instead of by day and repeated the analysis for Johnstone Strait. Sets per day and gear count data were calculated as before. Differences in total catch estimates for juvenile and adult chinook were less than 3%; an 8% increase was recorded for jack chinook, and a 10% increase for sockeye. When a similar comparison was done with the Juan de Fuca data, there was an increase of 21% in the catch estimate for juvenile chinook, 30% increase for jacks, 22% for adults, and a 12% increase for sockeye. Since there were such a large number of null sets in the catch data, large catches would tend to cause an increase in catch estimates when the data are pooled by week. The average catch per set will especially be affected when large catches are observed on days when few boardings are made. It is evident that due to the high variation in catch per set the level of stratification chosen could have a considerable affect on catch estimate.

For both Juan de Fuca and Johnstone Strait the effect of week and area could only account for 11% or less of the total variance in catch per set. This indicates that area and week contribute little to the total variance. Other parameters such as tide, vessel, open/beach set strategy, depth etc. need to be examined more closely when several years of data have been collected to determine what might be the cause(s) of the large variance in catch per set from day to day.

For Juan de Fuca, the additional stratification by line was very important. When calculations were repeated without stratifying the data by fishing line, the total catch estimates were considerably higher. The increase in the estimate for adults was 17%, for jacks 46%, for juveniles 50%, and for sockeye 84%. Even though the grouping of fishing lines into only two categories was somewhat crude these results show that

stratification by line was critical. More detailed information about catch per set by line as well as gear count need to be collected to further refine our catch estimates. Fleet dynamics may also have an effect on the stratification of catch per set by line. On a given day the fishing fleet is usually well spread out over all fishing lines during the morning hours but towards afternoon fishermen tend to concentrate in the first few fishing lines.

C. DATA CONSIDERATIONS

Our catch estimates could be significantly affected by the treatment of missing data cells, and whether our sampling was representative for the three variables used in the calculation. Consideration of these aspects was important in assessing the value of the bootstrap technique.

Treatment of missing data cells for catch per set and sets per day was dealt with by using the average value for the data collection in each area and time stratum as outlined in the methodology section. If data for a given day were significantly different than another day within the same week then pooling data by week may be a potential source of error. As indicated earlier, this source of error warrants consideration since catch per set data were highly skewed.

Filling in missing data cells for overflight data was also accomplished by using the mean for the week. This was done with some concern, since in 1986 differences in the overflight gear count between days in a given week and sub-area in Johnstone Strait varied considerably and in some cases was as high as 55%. Unfortunately, no similar comparison was available for this year. We could not possibly anticipate major shifts in effort, but it was assumed that the 10% error would account for most of the possible changes in effort from day to day. Comparison of the overflight gear count with sales slip data indicated that no consistent bias in the overflight data was evident. Further work is necessary to gain a better understanding of the error associated with overflight and fishery officer gear count estimates. There is likely considerable error associated with both techniques due to a number of factors including weather and movement of the fleet. It is imperative that gear count data be collected for each fishing day.

The question of representative sampling in reference to catch per set also presented some concerns. In Johnstone Strait, (Sunday evenings for example) or when equipment failures occurred, it may not have been possible to observe an adequate number of sets. Further, because vessel boardings were made on a

voluntary basis, some bias could be introduced by interviewing only those vessels that were receptive to our program. It could be the case that the more successful a skipper, the more receptive he would be to the program. In most areas relatively few skippers did not allow us to board, except in the lower Johnstone Strait sub-area (Stat. area 13), where at least 10% of the skippers refused boardings.

Some other sources of potential bias are also noted. Recording of chinook catch posed some problems when large catches of sockeye were encountered, especially when brailling took place. This was not a major concern in this survey, however, considering the small number (10) of large catches of sockeye (>500) encountered. When no opportunity for close examination was allowed, some juvenile coho or pink salmon may have been recorded as chinook or vice versa. A preliminary test of the accuracy of species identification by the field crew was accomplished by examining the scale data. Ageing technicians can quite readily identify the species from the scale patterns (Bilton et al. 1964). Out of 290 scales read only 2 (.7%) were incorrectly identified, one chinook was misidentified as a pink salmon and the other as a coho.

Since sets per day data were recorded each time a boarding was made, ample data were collected. The difficulty arises in trying to partition the effort expended between open and beach set strategy. No partitioning was attempted in the calculations for 1987. Some bias may be introduced if non-representative data were collected by type of set for a given day and a significant difference between open and beach catch per set existed. How the time at boarding and the number of sets made up to that time were recorded may also effect the accuracy of the information collected. For example, observers could have recorded the time of boarding to be the time they got on the vessel or when they were getting off. The number of sets made up to the time recorded could have included or excluded the set being monitored. Error would be introduced if the incorrect combination occurred.

In summary, this study provides us with an independent estimate of the chinook mortality during the Johnstone Strait and Juan de Fuca Strait sockeye, pink, and chum seine fisheries. Best estimates of total catch were presented based on catch per set, sets made per day, and gear count data. Further work will be required to refine the catch estimation techniques, compare the chinook mortality rates with factors such as total fishing effort and chinook stock size, and examine the changes in these variables over time.

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Table 1. The 1987 openings for the seine fishery.

Area	Dates of survey	Scheduled fishing dates
SOCKEYE FISHERY:		
Johnstone Strait	Aug. 2- 3	Aug. 2- 3
(Stat. area: 12,13)	Aug. 9-11	Aug. 9-11
	Aug. 16-17	Aug. 16-17
	Aug. 22-24	Aug. 22-24
	Sept. 1- 2	Sept. 1- 2
Sabine Channel	Aug. 16-17	Aug. 9-11
(Stat. area: 16)		Aug. 16-17
		Aug. 21-22
		Sept. 1- 2
Juan de Fuca Strait	Aug. 10-11	Aug. 10-11
(Stat. area: 20)	Aug. 22-24	Aug. 22-24
	Sept. 2	Sept. 2
CHUM FISHERY:		
Johnstone Strait	Sept. 21-22	Sept. 21-22
Juan de Fuca Strait	Sept. 27	Sept. 27

Table 2. Analysis of variance for chinook (adults, jacks, and juveniles combined) catch per set within and among days, by week and sub-area in Johnstone Strait.[1]

Week	Source of variation	DF	SS	MS	F_{obs}	$F_{0.05}$
Gordon Group						
Aug. 9-11	Model (among)	2	5.71	2.85	2.38	3.27
	Error (within)	35	42.00	1.20		
	Total	37	47.71			
Aug. 22-24	Model	1	0.67	0.67	0.05	4.38
	Error	19	263.14	13.85		
	Total	20	263.81			
North Shore						
Aug. 9-11	Model	2	87.18	43.59	7.89	3.34
	Error	28	154.75	5.53		
	Total	30	241.93			
Aug. 22-24	Model	1	0.07	0.07	1.38	4.08
	Error	38	1.83	0.05		
	Total	39	1.90			
Upper Johnstone Strait						
Aug. 9-11	Model	2	0.23	0.11	0.53	3.13
	Error	72	15.55	0.22		
	Total	74	15.78			
Aug. 22-24	Model	2	6.52	3.26	1.14	3.20
	Error	47	134.36	2.86		
	Total	49	140.88			

[1]Insufficient data available for Discovery Passage and Lower Johnstone Strait.

Table 3. Analysis of variance for sockeye catch per set within and among days, by week and sub-area in Johnstone Strait.[1]

Week	Source of variation	DF	SS	MS	F_{obs}	$F_{0.05}$
Gordon Group						
Aug. 9-11	Model	2	25,017	12,508	1.12	3.27
	Error	35	391,722	11,192		
	Total	37	416,740			
Aug. 22-24	Model	1	364	364	0.54	4.38
	Error	19	12,856	676		
	Total	20	13,220			
North Shore						
Aug. 9-11	Model	2	2,318	1,159	0.06	3.34
	Error	28	566,229	20,222		
	Total	30	568,547			
Aug. 22-24	Model	1	1,972	1,972	4.31	4.08
	Error	38	17,369	457		
	Total	39	19,341			
Upper Johnstone Strait						
Aug. 9-11	Model	2	165,818	82,909	2.19	3.13
	Error	72	2,726,766	37,871		
	Total	74	2,892,585			
Aug. 22-24	Model	2	54,975	27,487	5.67	3.20
	Error	47	227,900	4,848		
	Total	49	282,876			
Lower Johnstone Strait						
Aug. 9-11	Model	2	4,682	2,341	0.43	3.68
	Error	15	82,328	5,488		
	Total	17	87,011			
Aug. 22-24	Model	2	2,253	1,126	0.41	3.52
	Error	19	52,789	2,778		
	Total	21	55,043			

[1]Insufficient data available for Discovery Pass.

Table 4. Analysis of variance for chinook (adults, jacks, and juveniles) and sockeye catch per set within and among days by week for Juan de Fuca Strait.

Week	Source of variation	DF	SS	MS	F_{obs}	$F_{0.05}$
Chinook						
Aug. 9-11	Model	1	7.64	7.64	4.86	
	Error	40	62.92	1.57		5.42
	Total	41	70.57			
Aug. 22-24	Model	2	0.43	0.21	0.25	3.05
	Error	66	56.12	0.85		
	Total	68	56.55			
Sockeye						
Aug. 9-11	Model	1	361,575	361,575	10.16	5.42
	Error	40	1,423,294	35,582		
	Total	41	1,784,870			
Aug. 22-24	Model	2	106,619	53,309	5.19	3.05
	Error	66	677,801	10,269		
	Total	68	784,420			

Table 5. Available fishing time by fishery opening for statistical areas 12, 13, 16, and 20.

Date	Statistical area[1]	Time of opening[2]	Available fishing hours
	SOCKEYE FISHERY		
Aug. 2	12, 13	1800	3.5
Aug. 3	12, 13	0600	12.0
Aug. 9	12, 13	1800	3.5
Aug. 10	12, 13, 20	0600	15.5
Aug. 11	12, 13, 20	0600	12.0
Aug. 16	12, 13, 16	1800	3.5
Aug. 17	12, 13, 16	0600	12.0
Aug. 22	12, 13	1800	3.5
	20	0700	12.0
Aug. 23	12, 13	0600	15.5
	20	0700	12.0
Aug. 24	12, 13	0600	12.0
	20	0700	12.0
Sept. 1	12, 13	1800	3.5
Sept. 2	12, 13	0600	12.0
	20	0700	12.0
	CHUM FISHERY		
Sept. 21	12, 13	1600	3.5
Sept. 22	12, 13	0700	12.0
Sept. 27	20	0700	9.0

[1]Areas 12 and 13: Johnstone Strait
Area 16: Sabine Channel
Area 20: Juan de Fuca Strait
[2]Universal time

Table 6. Analysis of variance of sockeye catch per set within and among areas (Lower Johnstone Strait and Discovery Passage) for 1986.

	Source of variation	DF	SS	MS	% error	F_{obs}	$F_{0.05}$
Week 2	Model (among)	1	1,824	1,824	<1%		
	Error (within)	67	208,320	3,109	>99%	0.59	5.25
	Total	68	210,145				
Week 3	Model	1	218,747	218,747	5%		
	Error	114	4,205,025	36,886	95%	5.93	5.18
	Total	115	4,423,772				
Week 4	Model	1	107,826	107,826	<1%		
	Error	134	18,371,521	137,180	>99%	0.79	5.13
	Total	135	18,479,347				
Week 5	Model	1	2,295	2,295	2%		
	Error	39	1,145,486	3,732	98%	0.62	5.42
	Total	40	147,882				

Table 7. Numbers of different vessels boarded and total boardings made (in parenthesis) by area and date.

	SOCKEYE FISHERY										CHUM FISHERY				
	August										September				
Area	2	3	9	10	11	16	17	22	23	24	1	2	21	22	27
Gordon Group	3(3)	21(22)	7(7)	14(18)	13(13)	3(3)	20(22)	-	9(9)	12(12)	-	9(9)	5(8)	9(16)	-
North Shore	-	9(13)	3(5)	6(7)	11(19)	-	11(21)	-	11(24)	8(16)	4(6)	2(4)	-	-	-
Upper Johnstone Strait	5(5)	20(22)	13(15)	25(36)	22(24)	15(15)	35(40)	7(7)	20(22)	17(21)	6(6)	16(16)	6(6)	11(11)	-
Lower Johnstone Strait	6(6)	13(19)	1(1)	9(11)	4(6)	-	21(28)	5(5)	15(16)	1(1)	2(2)	5(5)	17(20)	15(16)	-
Discovery Passage	-	-	-	-	-	7(7)	-	-	-	-	-	-	-	-	-
Total Johnstone Strait	14(14)	63(76)	24(28)	54(72)	50(62)	25(25)	87(111)	12(12)	55(71)	38(50)	12(14)	32(34)	28(34)	35(43)	-
Sabine Channel	-	-	-	-	-	6(6)	20(24)	-	-	-	-	-	-	-	-
Juan de Fuca	-	-	-	23(29)	13(13)	-	-	33(37)	29(30)	2(2)	-	21(23)	-	-	16(21)

Table 8. Average catch per set by category compiled from data collected during the seine fishery.

SOCKEYE FISHERY

Gordon Group	Chinook			Sockeye
	Adult	Jack	Juvenile	
Aug. 2	0.00(0.00)[a]	0.00(0.00)	0.67(1.15)	55.00 (39.10)
Aug. 3	0.27(0.63)	0.14(0.47)	0.91(1.41)	55.40 (74.00)
Aug. 9	0.43(0.79)	0.57(0.98)	0.57(1.13)	19.10 (36.30)
Aug. 10	0.50(0.99)	0.00(0.00)	0.11(0.32)	89.30(131.80)
Aug. 11	0.46(0.66)	0.00(0.00)	0.23(0.44)	65.00 (86.00)
Aug. 16	0.00(0.00)	0.00(0.00)	0.33(0.58)	7.00 (11.30)
Aug. 17	0.14(0.35)	0.14(0.47)	0.50(0.21)	9.40 (9.10)
Aug. 22		NO DATA		
Aug. 23	1.67(2.06)	0.33(0.50)	0.67(1.00)	26.70 (24.90)
Aug. 24	1.08(2.27)	0.50(1.24)	0.50(1.17)	18.30 (26.80)
Sept. 1		NO DATA		
Sept. 2	0.44(0.73)	0.00(0.00)	0.44(1.01)	9.40 (8.90)
Mean[b]	0.44(1.08)	0.13(0.52)	0.35(0.86)	33.20 (68.30)

CHUM FISHERY

Sept. 21	0.50(1.07)	0.00(0.00)	0.00(0.00)	0.00 (0.00)
Sept. 22	0.00(0.00)	0.00(0.00)	0.06(0.25)	0.00 (0.00)

Table 8 (cont'd)

SOCKEYE FISHERY

North Shore	Chinook Adult	Chinook Jack	Chinook Juvenile	Sockeye
Aug. 2		NO DATA		
Aug. 3	2.31(2.59)	0.00(0.00)	2.23(1.48)	40.90 (41.70)
Aug. 9	3.80(5.50)	1.00(1.22)	0.60(0.89)	116.60(154.50)
Aug. 10	0.43(0.79)	0.00(0.00)	1.43(2.15)	116.00(154.50)
Aug. 11	0.53(0.90)	0.05(0.23)	0.58(1.46)	134.00(134.90)
Aug. 16		NO DATA		
Aug. 17	0.29(0.56)	0.00(0.00)	0.14(0.48)	20.90 (25.50)
Aug. 22		NO DATA		
Aug. 23	0.13(0.45)	0.04(0.20)	0.50(0.98)	28.20 (25.90)
Aug. 24	0.31(0.60)	0.06(0.25)	0.13(0.34)	13.90 (11.40)
Sept. 1	0.33(0.52)	0.17(0.41)	0.00(0.00)	3.50 (3.40)
Sept. 2	0.00(0.00)	0.00(0.00)	0.00(0.00)	3.00 (2.20)
Mean[b]	0.68(1.72)	0.08(0.35)	0.61(1.24)	50.80 (87.70)

CHUM FISHERY

Sept. 21	NO DATA
Sept. 22	NO DATA

Table 8 (cont'd)

SOCKEYE FISHERY

Upper Johnstone Strait	Chinook			Sockeye
	Adult	Jack	Juvenile	
Aug. 2	2.40(5.37)	0.00(0.00)	0.00(0.00)	38.20 (29.00)
Aug. 3	0.05(0.21)	0.00(0.00)	0.36(1.29)	51.40 (60.00)
Aug. 9	0.00(0.00)	0.07(0.26)	0.00(0.00)	27.40 (38.50)
Aug. 10	0.11(0 40)	0.08(0.37)	0.03(0.17)	66.80 (93.20)
Aug. 11	0.13(0.61)	0.00(0.00)	0.00(0.00)	150.90(323.20)
Aug. 16	0.13(0.52)	0.00(0.00)	0.00(0.00)	165.30(410.00)
Aug. 17	0.15(0.58)	0.10(0.38)	0.13(0.40)	32.60 (57.80)
Aug. 22	0.00(0.00)	0.14(0.38)	0.00(0.00)	121.30(151.70)
Aug. 23	0.68(1.70)	0.14(0.47)	0.45(1.10)	28.20 (59.50)
Aug. 24	0.19(0.51)	0.10(0.30)	0.05(0.22)	23.50 (27.90)
Sept. 1	0.00(0.00)	0.00(0.00)	0.00(0.00)	11.30 (19.50)
Sept. 2	0.13(0.34)	0.00(0.00)	0.00(0.00)	1.50 (2.80)
Mean[b]	0.20(1.00)	0.06(0.28)	0.10(0.55)	55.30(158.30)
	CHUM FISHERY			
Sept. 21	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00 (0.00)
Sept. 22	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.10 (0.30)

Table 8 (cont'd)

SOCKEYE FISHERY

Lower Johnstone Strait	Chinook			Sockeye
	Adult	Jack	Juvenile	
Aug. 2	1.67(4.08)	0.00(0.00)	0.00(0.00)	482.50(454.50)
Aug. 3	0.32(1.00)	0.00(0.00)	0.00(0.00)	6.40 (14.90)
Aug. 9	0.00(0.00)	0.00(0.00)	0.00(0.00)	20.00 (0.00)
Aug. 10	1.55(3.01)	0.36(0.81)	0.00(0.00)	55.90 (39.50)
Aug. 11	2.33(3.93)	0.00(0.00)	0.17(0.41)	82.50(115.50)
Aug. 16	NO DATA			
Aug. 17	0.21(0.69)	0.00(0.00)	0.07(0.26)	39.90 (66.80)
Aug. 22	0.20(0.45)	0.00(0.00)	0.00(0.00)	3.00 (3.00)
Aug. 23	0.19(0.54)	0.00(0.00)	0.13(0.34)	25.40 (59.30)
Aug. 24	0.00(0.00)	0.00(0.00)	0.00(0.00)	1.00 (0.00)
Sept. 1	0.00(0.00)	0.00(0.00)	0.00(0.00)	37.00 (46.70)
Sept. 2	0.80(0.84)	0.00(0.00)	0.00(0.00)	7.80 (6.70)
Mean[b]	0.61(1.62)	0.04(0.26)	0.05(0.21)	57.98(138.20)
CHUM FISHERY				
Sept. 21	0.30(0.80)	0.00(0.00)	0.05(0.22)	0.60 (2.20)
Sept. 22	0.19(0.40)	0.06(0.25)	0.00(0.00)	0.10 (0.30)
SOCKEYE FISHERY				
Johnstone Strait (all areas combined)				
Mean[b]	0.44(1.39)	0.08(0.38)	0.26(0.82)	54.75(137.69)

Table 8 (cont'd)

SOCKEYE FISHERY

Sabine Channel	Chinook Adult	Chinook Jack	Chinook Juvenile	Sockeye
Aug. 16	0.67(1.21)	0.17(0.41)	0.00(0.00)	36.00 (28.40)
Aug. 17	0.04(0.20)	0.00(0.00)	0.33(0.64)	76.10 (53.10)
Mean[b]	0.17(0.59)	0.03(0.18)	0.27(0.58)	68.10 (51.40)
Juan de Fuca Strait				
Aug. 9		NO DATA		
Aug. 10	0.17(0.54)	0.00(0.00)	0.28(0.70)	87.80 (90.40)
Aug. 11	0.54(0.52)	0.31(0.63)	1.08(1.38)	288.50(315.50)
Aug. 22	0.65(0.82)	0.14(0.42)	0.46(1.39)	132.40(122.30)
Aug. 23	1.07(1.68)	0.23(0.68)	0.83(1.18)	58.70 (69.30)
Aug. 24	2.00(0.00)	0.00(0.00)	0.00(0.00)	6.50 (4.90)
Sept. 1		NO DATA		
Sept. 2	0.83(0.94)	0.09(0.29)	0.43(0.99)	4.20 (6.70)
Mean[b]	0.68(1.02)	0.13(0.43)	0.55(1.10)	97.47(140.90)
		COHO FISHERY		
Sept. 27	0.10(0.30)	0.05(0.22)	0.19(0.51)	0.00 (0.00)

[a]Standard deviation in parenthesis.
[b]Weighted mean catch per set, all weeks combined.

Table 9. Two-way analysis of variance of catch per set vs area and week for Johnstone Strait.

	Source of variation	DF	SS	MS	F_{obs}	$F_{0.05}$
Jacks	Total	568	81.12			
	Model	20	4.73	0.24	1.70	2.09
	Error	548	76.38	0.14		
	Area	4	1.04	0.26	1.87	3.51
	Week	4	0.94	0.24	1.68	3.51
	Area and week	12	2.75	0.23	1.65	2.68
Juveniles	Total	568	382.46			
	Model	20	85.13	4.26	7.84	2.09
	Error	548	297.33	0.54		
	Area	4	26.54	6.64	12.23	3.51*
	Week	4	19.84	4.96	9.14	3.51*
	Area and week	12	38.75	3.23	5.95	2.68*
Adults	Total	568	1,098.16			
	Model	20	130.26	6.51	3.69	2.09
	Error	548	967.89	1.76		
	Area	4	21.54	5.38	3.05	3.51
	Week	4	18.22	4.56	2.58	3.51
	Area and week	12	90.50	7.54	4.27	2.68*
Sockeye	Total	568	10,733,525			
	Model	20	745,020	37,254	2.04	2.09
	Error	548	9,988,445	18,227		
	Area	4	114,774	28,686	1.57	3.51
	Week	4	423,223	105,805	5.80	3.51*
	Area and week	12	207,082	17,256	0.95	2.68

*Denotes significance

Table 10. Comparison between type of set and mean chinook catch per set by area.

	N	Adults	Jacks	Juveniles
Gordon Group				
Open	98	0.38(0.09)[1]	0.14(0.05)	0.38(0.09)
Beach	20	1.05(0.41)	0.25(0.20)	0.55(0.24)
North Shore				
Open	97	0.73(0.18)	0.08(0.04)	0.66(0.13)
Beach	6	0.50(0.34)	0	0.33(0.33)
Upper Johnstone Strait				
Open	123	0.16(0.10)	0.04(0.02)	0.09(0.05)
Beach	106	0.27(0.09)	0.08(0.03)	0.13(0.05)
Lower Johnstone Strait				
Open	30	0.13(0.08)	0	0.06(0.04)
Beach	67	0.85(0.27)	0.06(0.04)	0.04(0.02)
Discovery Passage				
Open	1	0	0	0
Beach	6	0.50(0.34)	0.17(0.17)	0.16(0.16)
Total[2]				
Open	349	0.38(0.05)	0.07(0.02)	0.33(0.04)
Beach	205	0.55(0.10)	0.09(0.03)	0.15(0.04)
Sabine Channel				
Open	17	0.06(0.06)	0.06(0.06)	0.23(0.14)
Beach	13	0.31(0.24)	0	0.31(0.17)
Juan de Fuca Strait				
Open	133	0.68(0.09)	0.13(0.04)	0.56(0.10)
Beach	-	-	-	-

[1]Standard error of the mean in parenthesis.
[2]All areas combined (Johnstone Strait).

Table 11. Summary of chinook biological samples collected during the sockeye fishery in Johnstone Strait.

Length (cm)	Juveniles M	Juveniles F	Juveniles U[1]	Length (cm)	Jacks M	Jacks F	Jacks U	Length (cm)	Adults M	Adults F	Adults U
								58			
23		1(7)		43		2(20)		60		1(12)	1
24		0		44	1(11)	0		64	1 (6)	0	0
25		0		45	1(11)	1(10)		70	1 (6)	0	0
26		0		46	2(22)	1(10)		73	1 (6)	0	1
27		0		47	0	0		74	1 (6)	0	1
28		0		48	0	0	1	75	0	0	1
29	1 (4)[a]	0	2	49	3(33)	0	1	76	0	1(12)	0
30	5(21)	0	0	50	1(11)	1(10)		79	1 (6)	1(12)	0
31	0	0	1	51	0	2(20)		80	0	0	2
32	0	0	3	52	1(11)	2(20)		81	0	0	1
33	0	1 (7)	4	53		0	1	82	0	1(12)	0
34	2 (8)	1 (7)	5	54		1(10)	1	85	2(13)	0	0
35	4(17)	1 (7)	1					86	2(13)	0	0
36	3(12)	1 (7)	7					90	0	1(12)	1
37	1 (4)	0	2					94	1 (6)	1(12)	0
38	2 (8)	1 (7)	5					101	0	2(25)	0
39	1 (4)	0	4					104	3(20)		0
40	3(12)	4(31)	4					110	1 (6)		0
41	0	1 (7)	1					111	1 (6)		0
42	2 (8)	2(15)	0					112			1
								122			1
Total	24	13	39		9	10	4		15	8	10
Weighted Mean Length	34.7	35.5			47.3	48.7			83.5	82.9	
Percent Immature	66%	92%			33%	90%			-	-	-
Sex Ratio	65%	35%			47%	53%			65%	35%	

[1] Fish could not be sampled for sex and maturity.

[a] Percent frequency in parenthesis.

Table 12. Summary of chinook biological samples from Johnstone Strait collected at the B.C. Packers Ltd. cannery in Vancouver.[1]

Length (cm)	Juveniles[2] M	Juveniles[2] F	Length (cm)	Jacks M	Jacks F
34	1(12)[a]		43	1 (5)	
35	0		44	2(10)	1
36	1(12)		45	0	
37	1(12)		46	0	
38	3(37)		47	0	
39	0		48	1 (5)	
40	0	1	49	0	
41	1(12)		50	1 (5)	
42	1(12)		51	3(15)	
			52	1 (5)	
			53	1 (5)	
			54	3(15)	
			55	2(10)	
			56	1 (5)	
			57	4(20)	
Total	8	1		20	1
Weighted Mean Length	36.8			49.7	
Percent Immature	87%	0		30%	0
Sex Ratio (% males)	89%			95%	

[1]Data collected by J. O. Thomas and Associates.

[2]For purposes of comparison with the survey data we split the cannery sample data into jacks and juveniles according to the criteria used for the survey data.

[a]Percent frequency in parenthesis.

Table 13. Summary of age samples collected during the survey.

JOHNSTONE STRAIT

Age[1]	M	F	U	T
0.1	22	11	31	64
0.2	4	2	1	7
0.3	2	2	2	6
0.4	4	2	1	7
1.0	3	1	4	8
1.1	2	2		4
1.3			1	1
Total	36	20	48	104
Unknown [2] : 51				

JUAN DE FUCA STRAIT

Age[1]	M	F	U	T
0.1	8	11	2	21
0.2	12	1	8	21
0.3	9	3	13	25
0.4	3	1	5	9
1.1	4	0	1	5
1.2	3	1	1	5
Total	39	17	30	86
Unknown [2] : 64				

Table 13 (cont'd)

SABINE CHANNEL

Age[1]	M	F	U	T
0.1	2	1		3
0.3		2		2
0.4	1			1
1.0	1			1
1.3	1			1
Total	5	3		8
Unknown[2]: 2				

[1]European notation: the first digit indicates the number of annuli formed in fresh water and the second digit indicates the number of annuli formed in the ocean.

[2]Unknown age: scales were unreadable.

Table 14. Average number of sets made per vessel by day and area.

	SOCKEYE FISHERY												CHUM FISHERY		
	August										September		September		
Study Area	2	3	9	10	11	16	17	22	23	24	1	2	21	22	27
Gordon Group	3.0	20.6	5.4	20.4	10.5	3.3	14.6	-	17.2	11.7	5.2	11.4	4.6	15.3	-
North Shore	-	10.6	5.6	16.7	17.6	-	15.1	-	19.4	13.3	6.5	11.7	-	-	-
Upper Johnstone Strait	2.6	15.4	4.8	15.1	11.4	4.9	12.2	3.8	14.5	11.1	3.3	8.1	-	10.8	-
Lower Johnstone Strait	4.2	12.0	5.3	18.5	18.0	-	16.8	3.2	11.4	20.0	3.4	6.8	3.6	6.8	-
Johnstone Strait (mean)	3.9	15.8	5.1	15.7	12.4	6.0	14.5	6.8	13.7	12.1	4.6	9.3	3.9	11.0	
Sabine Channel	-	-	-	-	-	4.3	11.0	-	-	-	-	-	-	-	-
Juan de Fuca Strait	-	-	-	11.8	7.3	-	-	8.4	8.5	11.5	-	9.1	-	-	7.6

Table 15. Overflight count of seiners by day for Johnstone Strait and Sabine Channel.

	SOCKEYE FISHERY											CHUM FISHERY		
	August											September		
Study Area	2	3[a]	9	10[b]	11[a]	16	17[a]	22	23[a]	24[a]	1	2[a]	21	22[a]
Gordon Group	35	-	20	33	-	22	-	29	-	-	23	-	32	-
North Shore	16	-	25	28	-	20	-	39	-	-	27	-	77	-
Upper Johnstone Strait	80	-	90	78	-	160	-	107	-	-	131	-	128	-
Lower Johnstone Strait	45	-	26	29	-	101	-	31	-	-	64	-	51	-
Discovery Passage	33	-	11	7	-	47	-	24	-	-	32	-	74	-
Total	209	-	172	175	-	350	-	230	-	-	277	-	362	-
Sabine Channel	-	-	15	14	-	43	-	15	-	-	16	-	-	-

[a] No overflight was made.

[b] Fishery officer count taken on the fishing grounds.

Table 16. Number of vessels that reported catch by week from sales slip data compared with overflight gear count.

Area	Week	Sales slip count[1]	Overflight count
	SOCKEYE FISHERY		
Johnstone Strait (Stat. area: 12, 13)	Aug. 2- 3	173	209
	Aug. 9	192	172
	Aug. 10		175
	Aug. 16-17	364	350
	Aug. 22-24	251	230
	Sept. 1- 2	278	277
Juan de Fuca Strait (Stat. area: 20)	Aug. 10	114	122
	Aug. 22	179	182
	Sept. 1	143	143
Sabine Channel (Stat. area: 16)	Aug. 16-17	50	43
	CHUM FISHERY		
Johnstone Strait	Sept. 21-22	403	362
	COHO FISHERY		
Juan de Fuca Strait	Sept. 27	105	118

[1]Unique CFV numbers delivering catch by statistical area, weekly totals only.

Table 17. Comparison of bootstrap estimates and sales slip data (numbers caught) by week for Johnstone Strait and Sabine Channel.

SOCKEYE FISHERY

	Adult	Jack	Juvenile	Sockeye
Johnstone Strait				
Aug. 2- 3	2,297[a]	99	1,722	281,541
	(702-4,923)[b]	(0-372)	(783-3,034)	(110,454-362,550)
	1,802[c]	473	[d]	165,265
Aug. 9-11	4,214	767	1,201	516,815
	(1,728-5,888)	(245-1,330)	(551-2,028)	(361,722-672,237)
	2,183	808	[d]	520,358
Aug. 16-17	1,384	303	672	277,388
	(417-3,480)	(41-1,059)	(201-1,814)	(148,003-667,468)
	2,025	468	[d]	250,831
Aug. 22-24	3,157	882	1,950	214,170
	(1,646-5,151)	(366-1,597)	(1,079-2,826)	(128,210-316,568)
	2,776	883	[d]	131,426
Sept. 1- 2	967	47	171	27,123
	(264-1,487)	(0-258)	(0-547)	(10,064-40,266)
	1,612	327	[d]	27,602
Total	12,019	2,098	5,716	1,317,037
	(7,964-15,903)	(1,261-3,195)	(3,883-7,969)	(969,611-1,657,509)
	10,398	2,959	[d]	1,095-482
Sabine Channel				
Aug. 16-17	141	31	218	56,955
	(17-396)	(0-112)	(45-455)	(31,328-76,106)
	162	126	[d]	39,123

CHUM FISHERY

Johnstone Strait				
Sept. 21-22	194	21	39	46,335
	(10-482)	(0-104)	(0-161)	(18,533-106,534)
	286	65	[d]	38,796

[a] Bootstrap estimates.

[b] Upper and lower 95% confidence limits.

[c] Sales slip data collected by the Dept. of Fisheries and Oceans, (March 1989).

[d] No data recorded for juveniles in sales slip data.

Table 18. Comparison of bootstrap estimates and sales slip data (numbers caught) by statistical area for Johnstone Strait.

SOCKEYE FISHERY

Statistical Area	Adult	Jack	Juvenile	Sockeye
12	7,120[a]	1,786	5,204	878,434
	(4,904-10,311)[b]	(1,083-2,686)	(3,696-7,718)	(682,305-1,114,697)
	7,078[c]	1,978	[d]	674,998
13	4,899	312	512	483,603
	(1,983-6,432)	(11-795)	(44-1,289)	(207,235-723,751)
	2,984	601	[d]	378,742
Total	12,019	2,098	5,716	1,317,037
	(7,964-15,903)	(1,261-3,195)	(3,883-7,969)	(969,611-657,509)
	10,398	2,959	[d]	1,095,482

CHUM FISHERY

	Adult	Jack	Juvenile	Chum
12	74	0	30	36,618
	(0-281)	-	(0-153)	(13,465-98,576)
	216	45	[d]	26,875
13	120	21	10	9,716
	(0-309)	(0-104)	(0-52)	(2,137-25,440)
	61	16	[d]	13,911
Total	194	21	39	46,335
	(10-482)	(0-104)	(0-161)	(18,533-106,534)
	286	65	[d]	38,796

[a] Bootstrap estimates.

[b] Upper and lower 95% confidence limits.

[c] Sales slip data collected by the Dept. of Fisheries and Oceans (March 1989).

[d] No data recorded for juveniles in sales slip data.

Table 19. Summary of catch per set by fishing line for the Juan de Fuca Strait sockeye fishery.[1]

Fishing line	Chinook			Sockeye
	Adult	Jack	Juvenile	
1	0.68(0.97)[a]	0.16(0.44)	0.78(1.20)	130.08(131.88)
2	0.89(1.41)	0.08(0.28)	0.73(1.52)	114.32(181.08)
3	0.50(0.74)	0.27(0.77)	0.45(0.80)	134.54(192.59)
4	0.80(1.31)	0.20(0.63)	0.60(1.35)	35.20 (30.16)
5	0.80(1.30)	0.20(0.45)	0	34.00 (40.53)
6	0	0	0	16.00 (24.80)
7	1.00	0	0	12.50 (16.67)
8	0	0	0	35.40 (40.50)
9	1.00	0	0.50(0.71)	52.50 (67.17)
10	0.26(0.41)	0	0	14.67 (10.68)
11	1.50(0.70)	0	0.50(0.71)	31.00 (41.01)
12	2.00	0	0	0

[1]Data from week 2 and 4 combined.
[a]Standard deviation in parenthesis.

Table 20. Analysis of variance of catch per set vs week for Juan de Fuca Strait sockeye seine fishery.

	Source of variation	DF	SS	MS	F_{obs}	$F_{0.05}$
Juveniles	Total	133	177.13			
	Model (week)	2	.57	.28	0.21	3.06
	Error	131	176.56	1.35		
Jacks	Total	133	27.58			
	Model (week)	2	.22	.11	0.54	3.06
	Error	131	27.36	.21		
Adults	Total	133	153.20			
	Model (week)	2	9.49	4.74	4.33	3.06*
	Error	131	143.70	1.09		
Sockeye	Total	133	2,885,901			
	Model (week)	2	315,608	157,804	8.04	3.06*
	Error	131	2,570,292	19,620		

*denotes significance

Table 21. Comparison of chinook catch per set vs depth in Juan de Fuca sockeye seine fishery.

Depth (fm)	N	AVERAGE CATCH PER SET			
		CHINOOK			SOCKEYE
		Adult	Jack	Juvenile	
25-35	4	2.75	0.00	1.25	22.25
35-45	8	2.00	0.00	2.75	48.25
45-55	12	0.92	0.33	0.83	82.41
55-65	10	0.80	0.00	0.20	61.60
65-75	10	0.90	0.00	0.30	49.70
75-85	5	0.40	0.20	0.60	207.00
85-95	4	0.75	0.00	0.00	1.25
95-105	6	1.33	0.17	0.17	50.83
105-115	3	0.00	0.00	0.33	36.66
25-65	34	1.35	0.18	1.15	61.18
65-115	29	0.76	0.07	0.27	67.31

Table 22. Summary of chinook biological samples collected during the sockeye fishery in Juan de Fuca Strait.

Length (cm)	Juveniles M	Juveniles F	Juveniles U[1]	Length (cm)	Jacks M	Jacks F	Jacks U	Length (cm)	Adults M	Adults F	Adults U
37				43	1 (5)			58	1 (4)	2(18)	
38		1(12)		44	2(11)	2(20)		60	1 (4)	0	
39	3(30)	1(12)		45	0	0		62	1 (4)	0	
40	2(20)	2(25)		46	5(28)	2(20)		64	0	0	1
41	1(10)	3(38)		47	1 (5)	0		65	1 (4)	0	0
42	4(40)	1(12)		48	2(11)	1(10)		66	1 (4)	0	0
				49	1 (5)	0		67	1 (4)	0	0
				50	1 (5)	1(10)		68	2 (8)	0	0
				51	1 (5)	1(10)		69	0	0	1
				52	0	1(10)		70	1 (4)	0	0
				53	2(11)	1(10)		71	2 (8)	0	1
				54	0	0		72	1 (4)	0	0
				55	0	0		73	1 (4)	0	1
				56	0	0		74	0	0	1
				57	2(11)	1(10)		75	0	0	1
								76	0	0	1
								77	1 (4)	1 (9)	1
								78	1 (9)	0	0
								79	1 (4)	0	1
								80	0	2 (8)	1
								81	2 (8)	0	1
								82	1 (4)	1 (9)	1
								83	1 (4)	0	0
								84	1 (4)	0	1
								86	0	0	2
								87	0	0	2
								88	3(12)	0	1
								90	1 (4)	0	0
								91		2(18)	1
								93		1 (9)	0
								95		0	1
								96		1 (9)	0
								97		0	1
								100		0	1
								103		0	1
								107		1 (9)	0
								118			1
Total	10	8	-		18	10	-		25	11	24
Weighted Mean Length	40.6	39.9			47.1	49.1			71.4	82.2	
Percent Immature	80%	100%	-		83%	100%	-		-	-	-
Sex Ratio	56%	44%			64%	36%			69%	31%	

Table 23. Summary of chinook biological samples from Juan de Fuca Strait collected at the B.C. Packers Ltd. cannery in Vancouver.[1]

Length (cm)	Juveniles[2] M	Juveniles[2] F	Length (cm)	Jacks M	Jacks F
33	1 (4)[a]		43	5 (9)	3(15)
34	0		44	6(11)	2(10)
35	2 (7)		45	5 (9)	6(30)
36	2 (7)	1 (9)	46	10(19)	2(10)
37	2 (7)	2(18)	47	5 (9)	1 (5)
38	4(14)	1 (9)	48	5 (9)	1 (5)
39	3(11)	1 (9)	49	2 (4)	2(10)
40	2 (7)	2(18)	50	4 (7)	0
41	3(11)	3(27)	51	0	0
42	9(32)	1 (9)	52	0	0
			53	4 (7)	2(10)
			54	1 (2)	0
			55	1 (2)	1 (5)
			56	2 (4)	
			57	4 (7)	
Total	28	11		54	20
Weighted Mean Length	39.2	39.1		47.6	46.6
Percent Immature	39%	100%		46%	100%
Sex Ratio (% males)	72%			73%	

[1] Data collected by J. O. Thomas and Associates.

[2] For purposes of comparison with the survey data we split the cannery sample data into jacks and juveniles according to the criteria used for the survey data.

[a] Percent frequency in parenthesis.

Table 24. Overflight count of seiners by day and geographic point for Juan de Fuca Strait.

	SOCKEYE FISHERY		COHO FISHERY	
	August		September	
Area	10	22	1[a]	27[a]
Bonilla Point	59	65		
Owen Point	55	37		
San Juan Harbour	-	28		
Sombrio Point	8	30		
Jordan River	-	16		
Sheringham Point	-	6		
Total	122	182	143	118

[a]No breakdown was available.

Table 25. Comparison of bootstrap estimates and sales slip data (numbers caught) by week for Juan de Fuca Strait.

SOCKEYE FISHERY

	Adult	Jack	Juvenile	Sockeye
Aug. 9-11	1,516[a]	253	994	169,378
	(974-2,104)[b]	(88-493)	(439-1,515)	(121,834-245,121)
	1,583[c]	1,125	[d]	175,513
Aug. 22-24	2,671	464	1,721	288,548
	(1,812-3848)	(185-915)	(1,012-2,756)	(219,044-368-530)
	2,740	1,901	[d]	234,911
Sept. 1- 2	1,102	115	582	5,523
	(375-2,203)	(0-445)	(0-1,684)	(1,270-13,069)
	940	387	[d]	4,322
Total	5,289	842	3,297	463,449
	(3,818-6,398)	(503-1,401)	(2,291-4,560)	(359,598-648,140)
	5,263	3,413	[d]	414,746

COHO FISHERY

Sept. 27	88	44	182	60,348
	(0-341)	(0-226)	(0-599)	(30,053-106,444)
	266	380	[d]	77,651

[a]Bootstrap estimates.
[b]Upper and lower 95% confidence limits.
[c]Sales slip data collected by the Dept. of Fisheries and Oceans, (March 1989).
[d]No data recorded for juveniles in sales slip data.

Table 26. Sales slip catch data by area for 1975-1987 seine fisheries.[1]

Area	Year	Chinook		Sockeye
		Adult	Jack	
Johnstone Strait	1975	23,022	13,405	110,150
	1976	22,491	20,523	388,548
	1977	39,015	15,504	443,691
	1978	45,238	25,430	2,942,207
	1979	25,910	11,894	889,483
	1980	25,187	12,416	929,330
	1981	24,207	13,061	2,596,192
	1982	23,133	9,650	1,360,430
	1983	24,590	22,262	1,963,716
	1984	14,315	12,823	895,463
	1985	32,790	4,401	2,293,580
	1986	12,937	3,332	1,442,880
	1987	10,560	3,005	1,084,361
Juan de Fuca	1975	5,937	18,097	38,417
	1976	6,190	23,905	505,599
	1977	15,079	40,382	419,356
	1978	6,215	16,036	353,708
	1979	7,036	25,353	278,622
	1980	889	3,302	52,551
	1981	6,369	17,023	205,974
	1982	4,441	8,175	1,438,107
	1983	145	3,157	2,890
	1984	3,919	13,602	421,721
	1985	13,349	26,274	2,281,205
	1986	11,879	39,522	1,673,063
	1987	5,358	3,803	401,843

[1] Total catch in pieces.

Table 27. Comparison of the commercial seine catch by species during the survey and total commercial catch for 1987.

Statistical Area	Chinook	Sockeye	Chum	Pink
Johnstone Strait				
Catch recorded during survey[a]	13,213	1,084,124	24,805	1,390,085
Total 1987[a] catch	13,565	1,084,361	74,233	1,405,201
Difference	2%	<1%	67%	1%
Juan de Fuca Strait				
Catch recorded during survey[a]	8,488	401,824	698	493,544
Total 1987[a] catch	9,161	401,843	11,685	496,669
Difference	7%	<1%	94%	<1%

[a]Sales slip data.

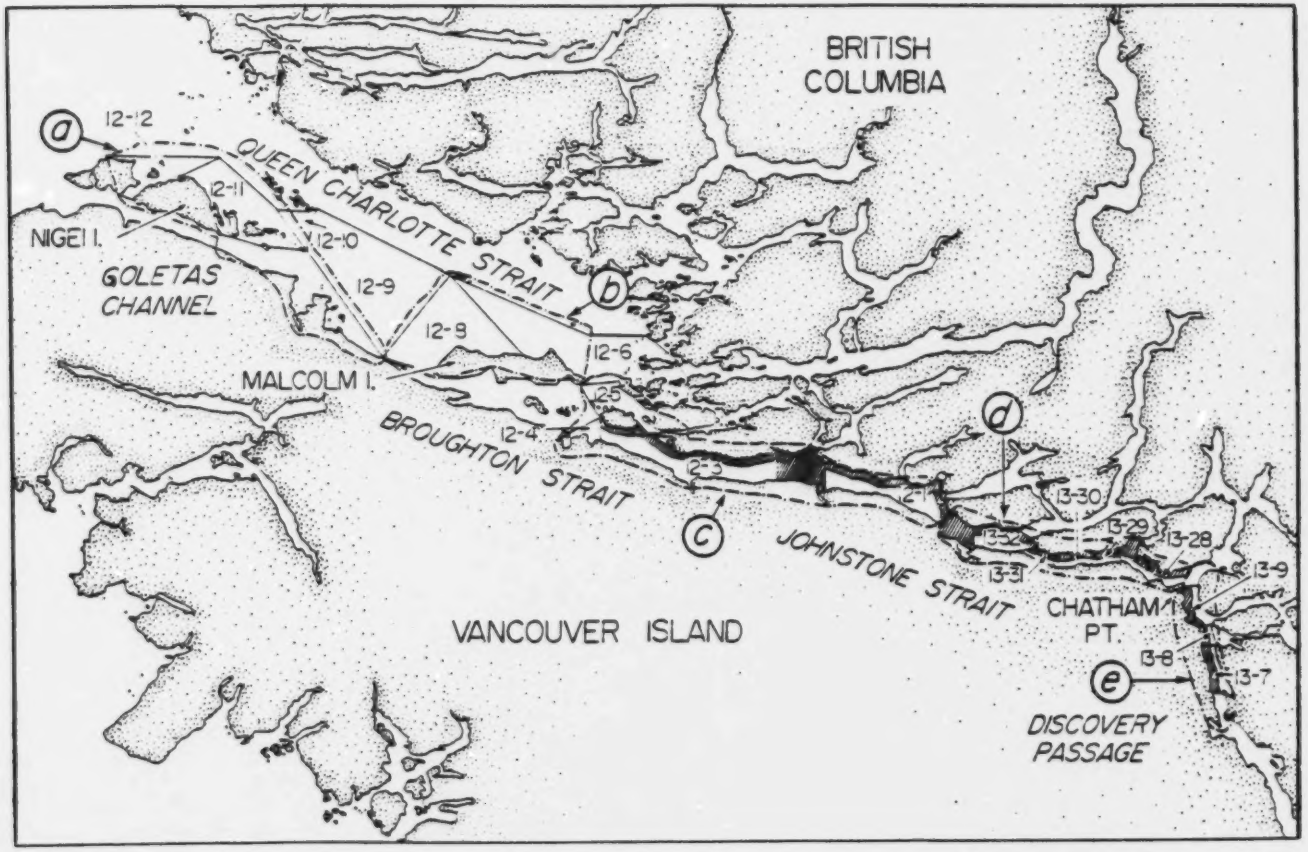


Fig. 1. Locations of management areas and study areas (a - Gordon Group, b - North Shore, c - Upper Johnstone Strait, d - Lower Johnstone Strait, e - Discovery Passage). Hatched sections represent areas closed to commercial fishing.

Fig. 2. Locations of management and study areas (hatched) in Sabine Channel, Georgia Strait.

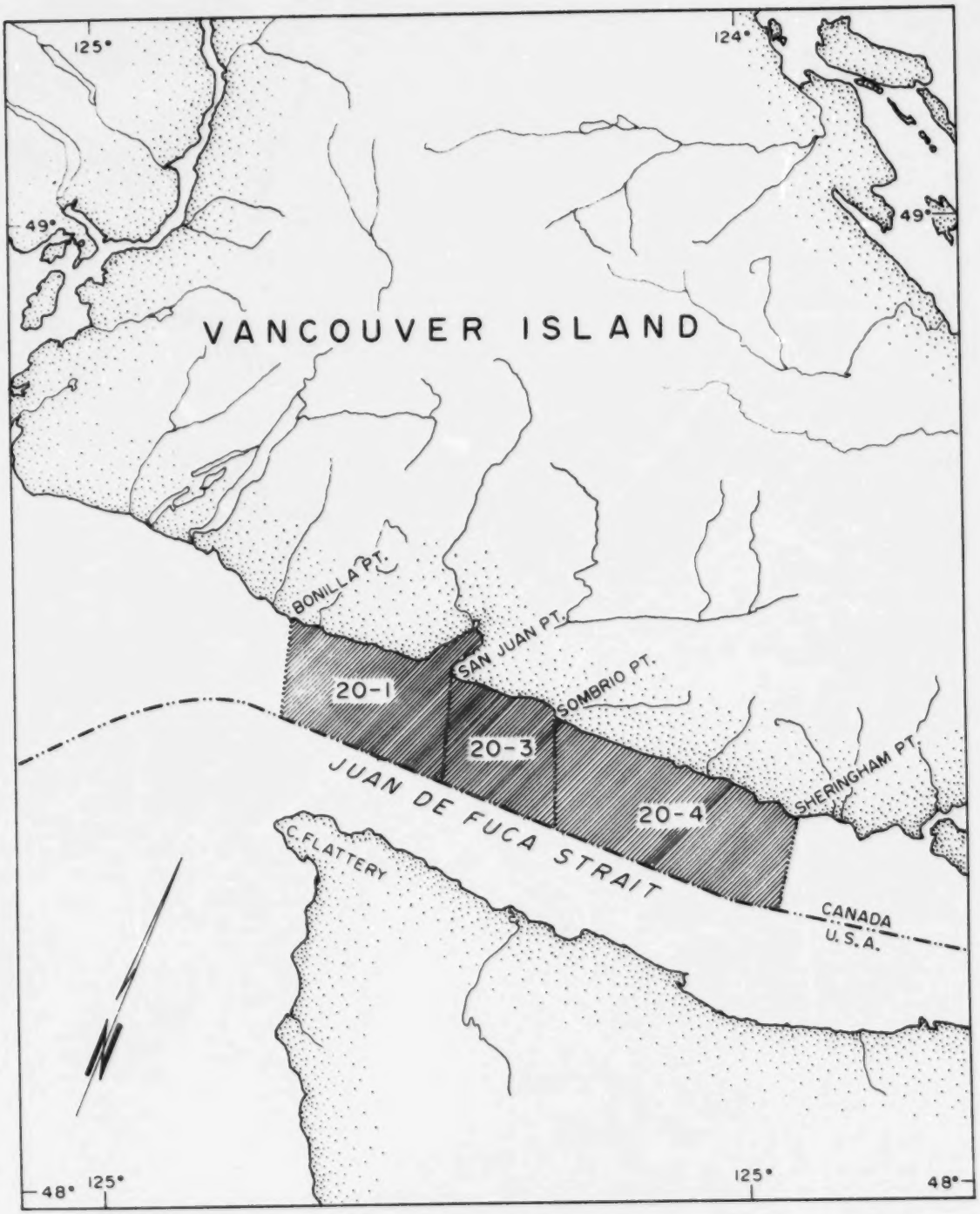
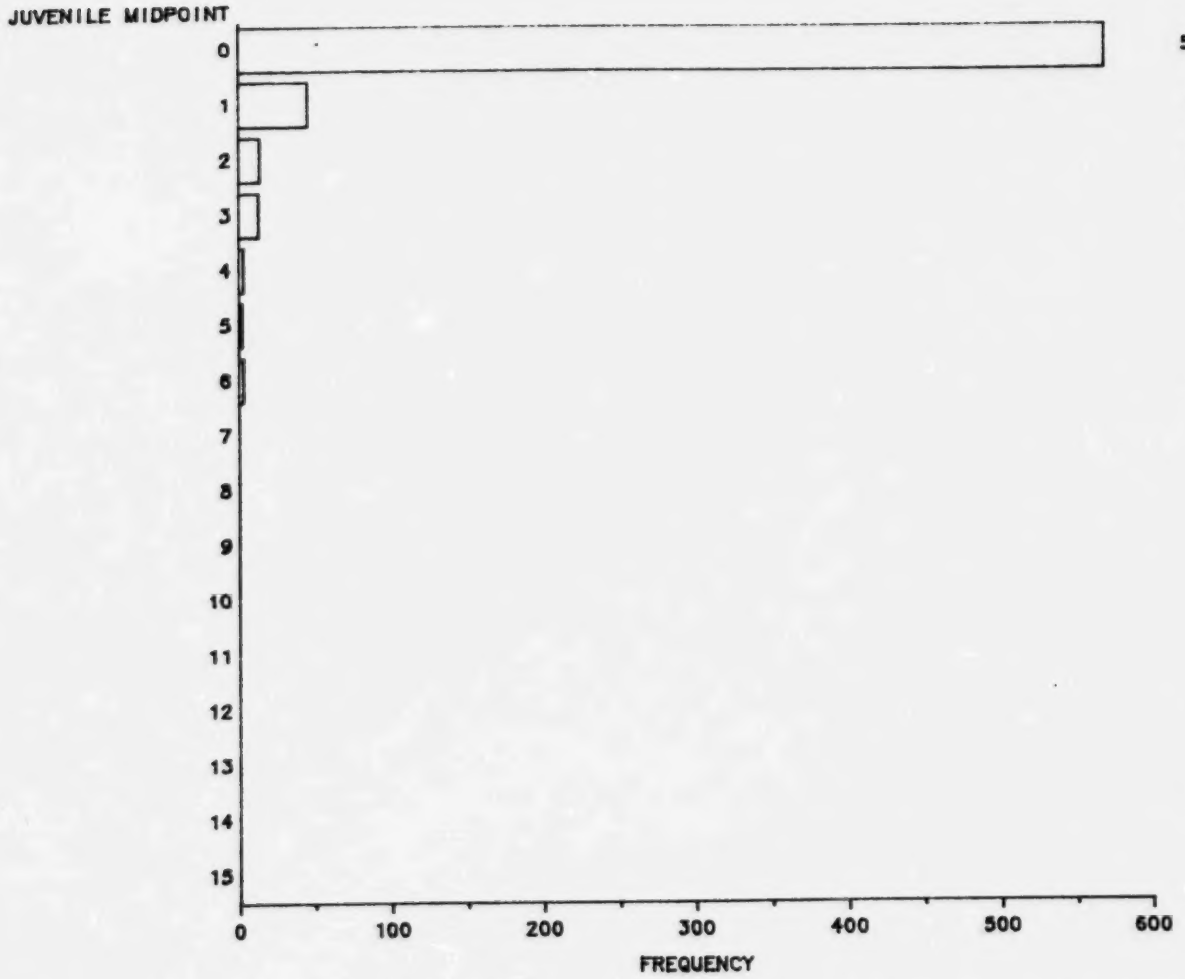


Fig. 3. Locations of management and study areas (hatched) in Juan de Fuca Strait.

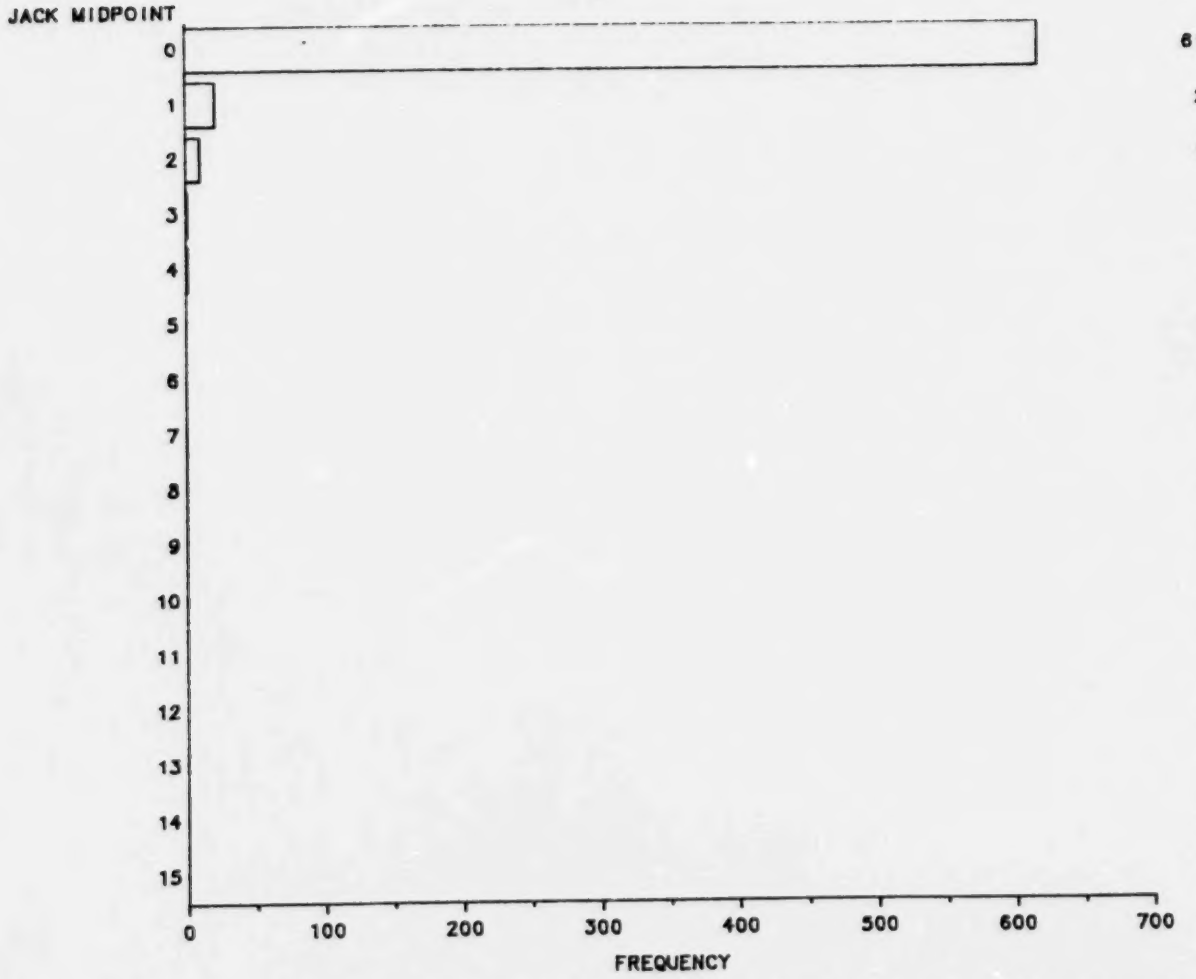
FREQUENCY HISTOGRAM OF CATCH/SET FOR JUVENILE CHINOOK



JUVENILE MIDPOINT	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0	566	566	87.62	87.62
1	45	611	6.97	94.58
2	14	625	2.17	96.75
3	13	638	2.01	98.76
4	3	641	0.46	99.23
5	2	643	0.31	99.54
6	3	646	0.46	100.00
7	0	646	0.00	100.00
8	0	646	0.00	100.00
9	0	646	0.00	100.00
10	0	646	0.00	100.00
11	0	646	0.00	100.00
12	0	646	0.00	100.00
13	0	646	0.00	100.00
14	0	646	0.00	100.00
15	0	646	0.00	100.00

Fig. 4. Frequency histogram of juvenile chinook catch per set in Johnstone Strait.

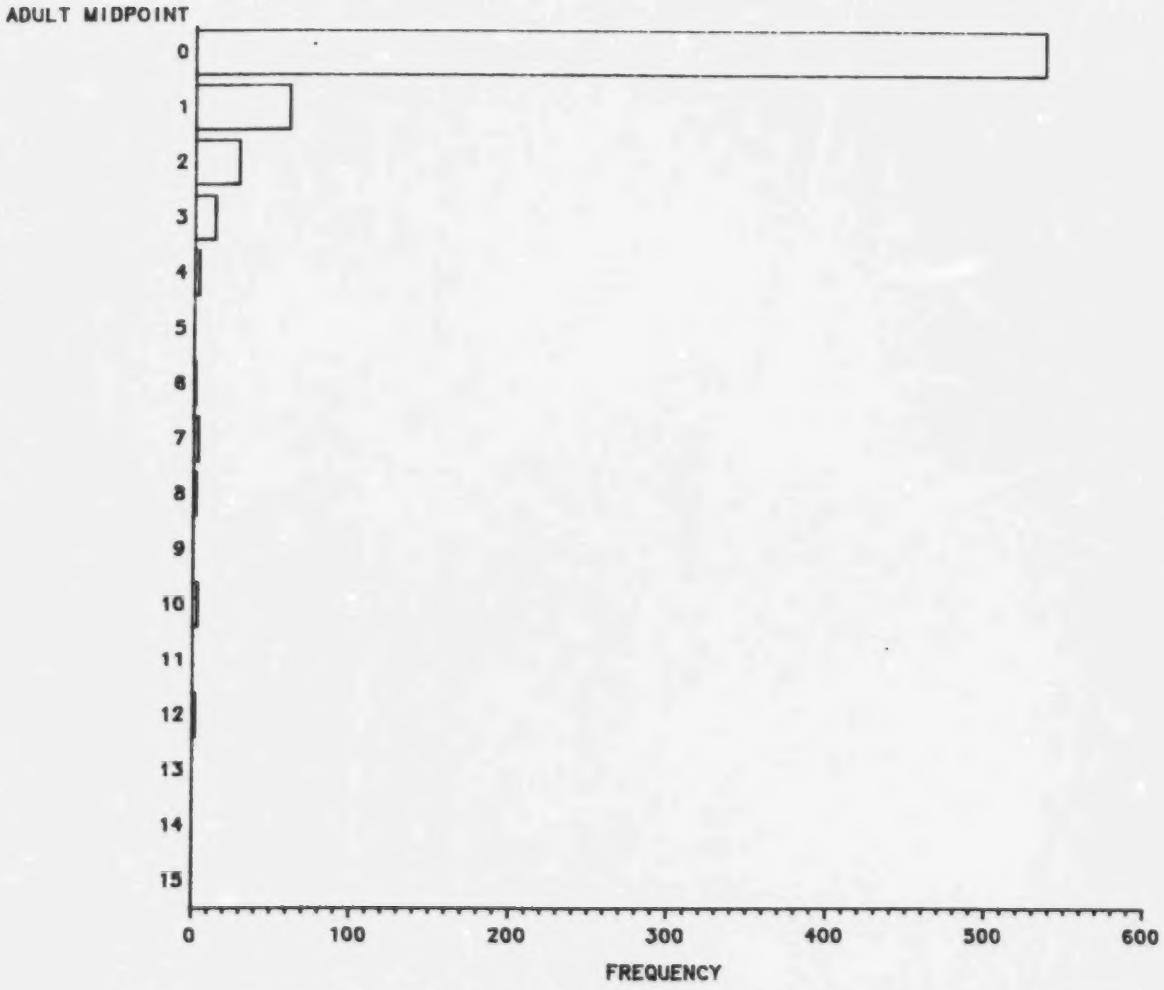
FREQUENCY HISTOGRAM OF CATCH/SET FOR JACK CHINOOK



JACK MIDPOINT	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0	613	613	94.89	94.89
1	21	634	3.25	98.14
2	10	644	1.55	99.69
3	1	645	0.15	99.85
4	1	646	0.15	100.00
5	0	646	0.00	100.00
6	0	646	0.00	100.00
7	0	646	0.00	100.00
8	0	646	0.00	100.00
9	0	646	0.00	100.00
10	0	646	0.00	100.00
11	0	646	0.00	100.00
12	0	646	0.00	100.00
13	0	646	0.00	100.00
14	0	646	0.00	100.00
15	0	646	0.00	100.00

Fig. 5. Frequency histogram of jack chinook catch per set in Johnstone Strait.

FREQUENCY HISTOGRAM OF CATCH/SET FOR ADULT CHINOOK

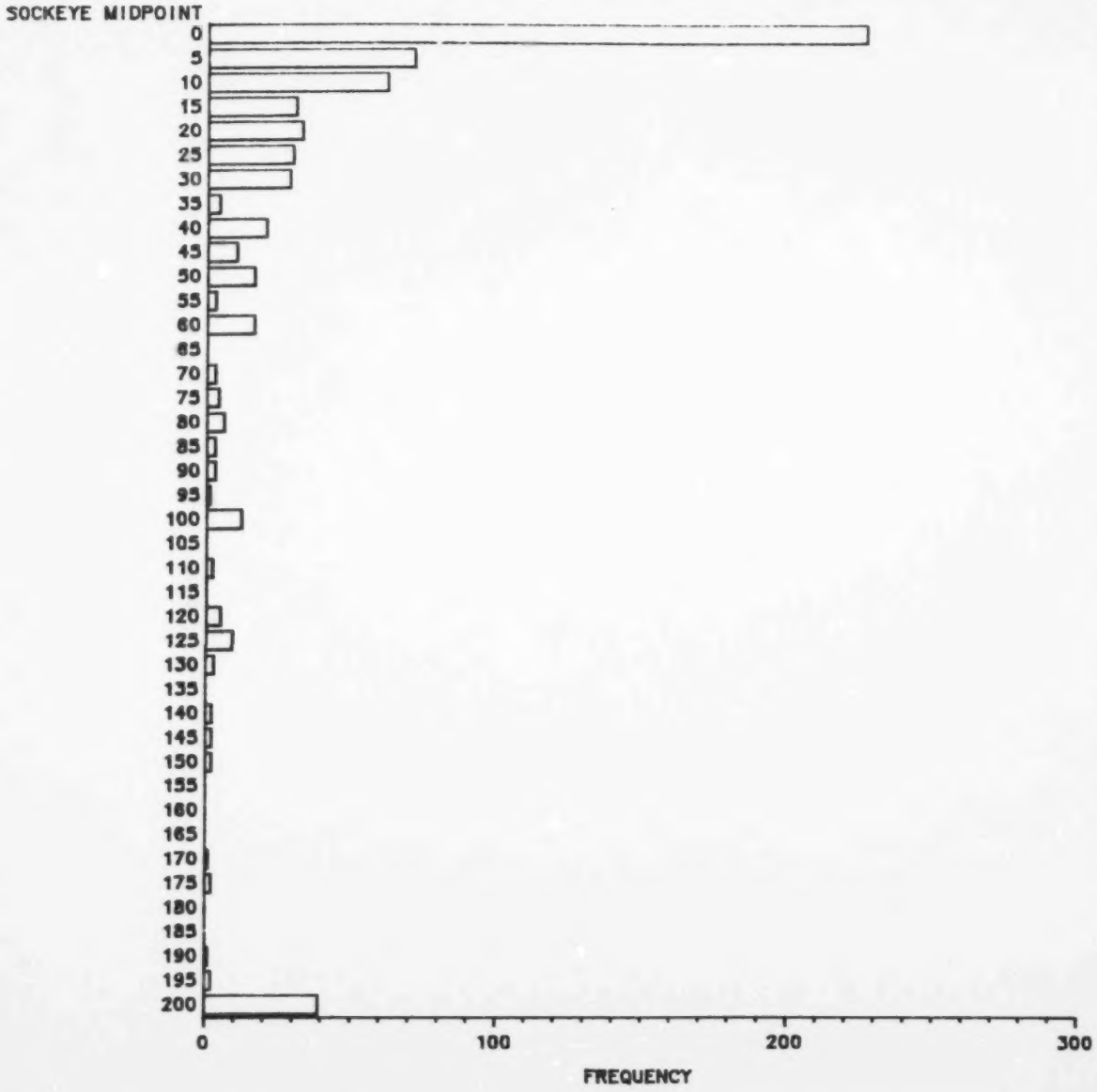


	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0	532	532	82.35	82.35
1	59	591	9.13	91.49
2	28	619	4.33	95.82
3	13	632	2.01	97.83
4	3	635	0.46	98.30
5	0	635	0.00	98.30
6	1	636	0.15	98.45
7	3	639	0.46	98.92
8	2	641	0.31	99.23
9	0	641	0.00	99.23
10	3	644	0.46	99.69
11	0	644	0.00	99.69
12	2	646	0.31	100.00
13	0	646	0.00	100.00
14	0	646	0.00	100.00
15	0	646	0.00	100.00

Fig. 6. Frequency histogram of adult chinook catch per set in Johnstone Strait.

Fig. 7. Frequency histogram of sockeye catch per set in Johnstone Strait.

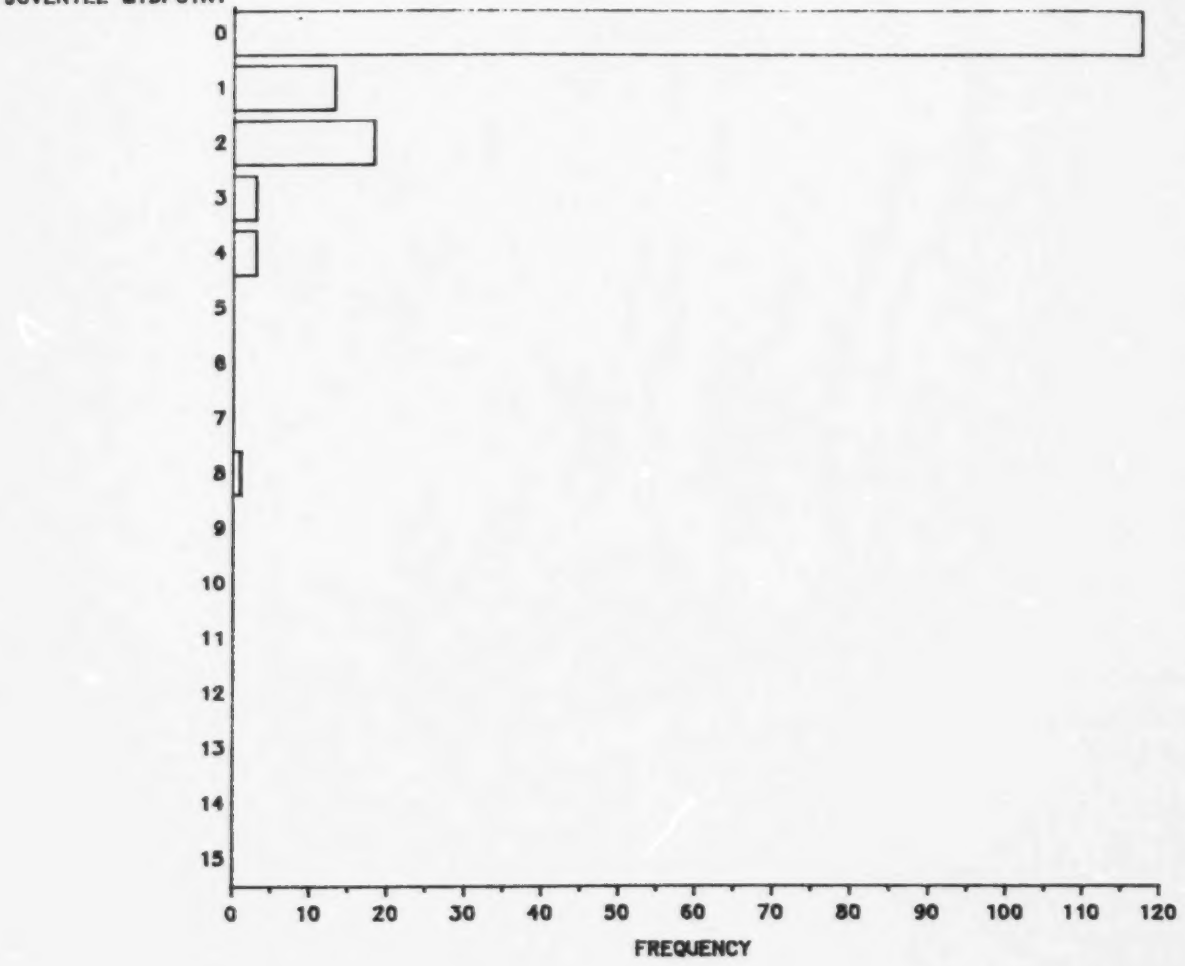
FREQUENCY HISTOGRAM OF CATCH/SET FOR SOCKEYE



FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
225	225	34.83	34.83
70	295	10.84	45.67
61	356	9.44	55.11
30	386	4.64	59.75
32	418	4.95	64.71
29	447	4.49	69.20
28	475	4.33	73.53
4	479	0.62	74.15
20	499	3.10	77.24
10	509	1.55	78.79
16	525	2.48	81.27
3	528	0.46	81.73
16	544	2.48	84.21
0	544	0.00	84.21
3	547	0.46	84.67
4	551	0.62	85.29
6	557	0.93	86.22
3	560	0.46	86.69
3	563	0.46	87.15
1	564	0.15	87.31
12	576	1.86	89.16
0	576	0.00	89.16
2	578	0.31	89.47
0	578	0.00	89.47
5	583	0.77	90.25
9	592	1.39	91.64
3	595	0.46	92.11
0	595	0.00	92.11
2	597	0.31	92.41
2	599	0.31	92.72
2	601	0.31	93.03
0	601	0.00	93.03
0	601	0.00	93.03
0	601	0.00	93.03
1	602	0.15	93.19
2	604	0.31	93.50
0	604	0.00	93.50
0	604	0.00	93.50
1	605	0.15	93.65
2	607	0.31	93.96
39	646	6.04	100.00

Fig. 8. Frequency histogram of juvenile chinook catch per set in Juan de Fuca Strait.

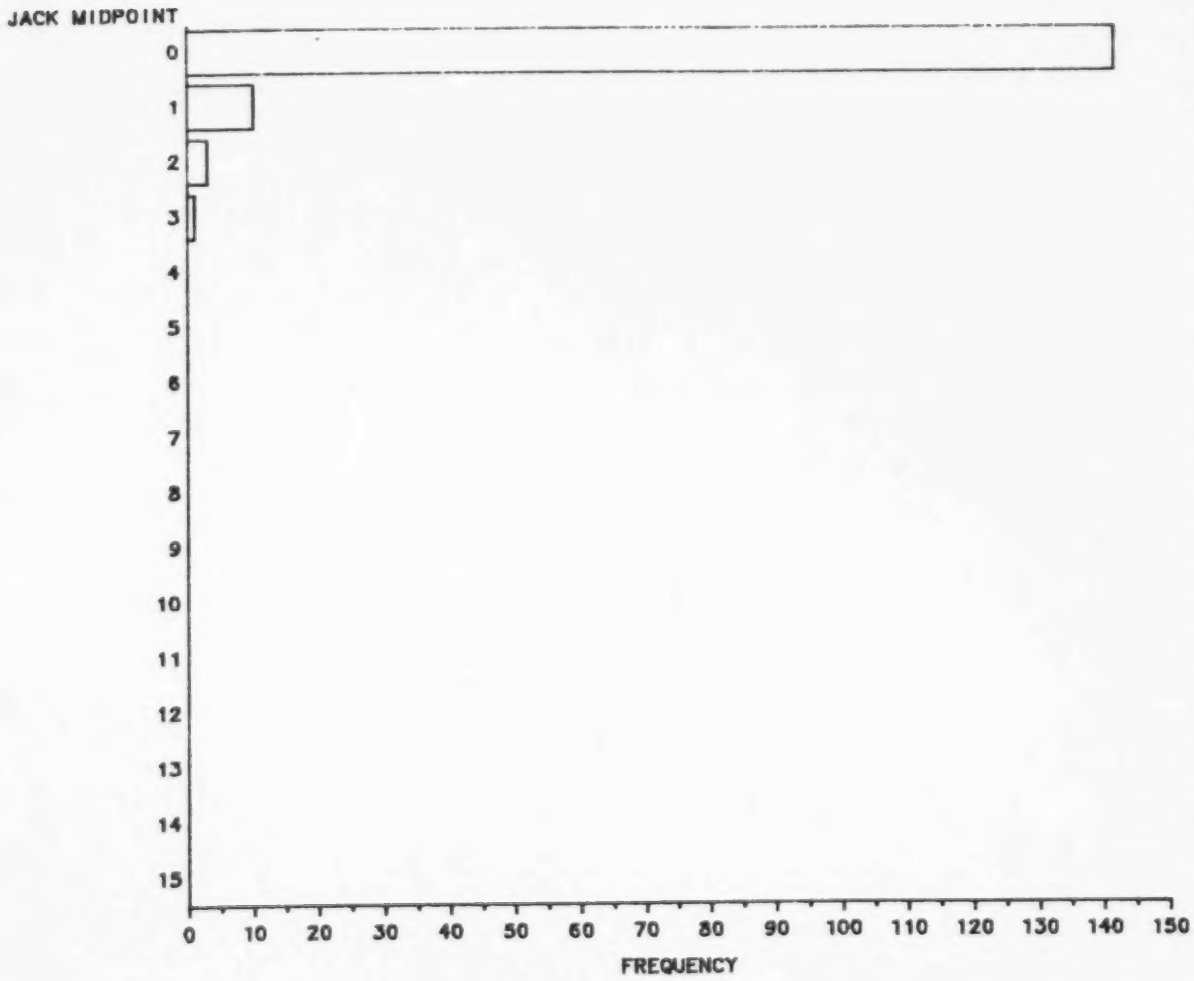
FREQUENCY HISTOGRAM OF CATCH/SET FOR JUVENILE CHINOOK



JUVENILE MIDPOINT	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0	117	117	75.48	75.48
1	13	130	8.39	83.87
2	18	148	11.61	95.48
3	3	151	1.94	97.42
4	3	154	1.94	99.35
5	0	154	0.00	99.35
6	0	154	0.00	99.35
7	0	154	0.00	99.35
8	1	155	0.65	100.00
9	0	155	0.00	100.00
10	0	155	0.00	100.00
11	0	155	0.00	100.00
12	0	155	0.00	100.00
13	0	155	0.00	100.00
14	0	155	0.00	100.00
15	0	155	0.00	100.00

Fig. 9. Frequency histogram of jack chinook catch per set in Juan de Fuca Strait.

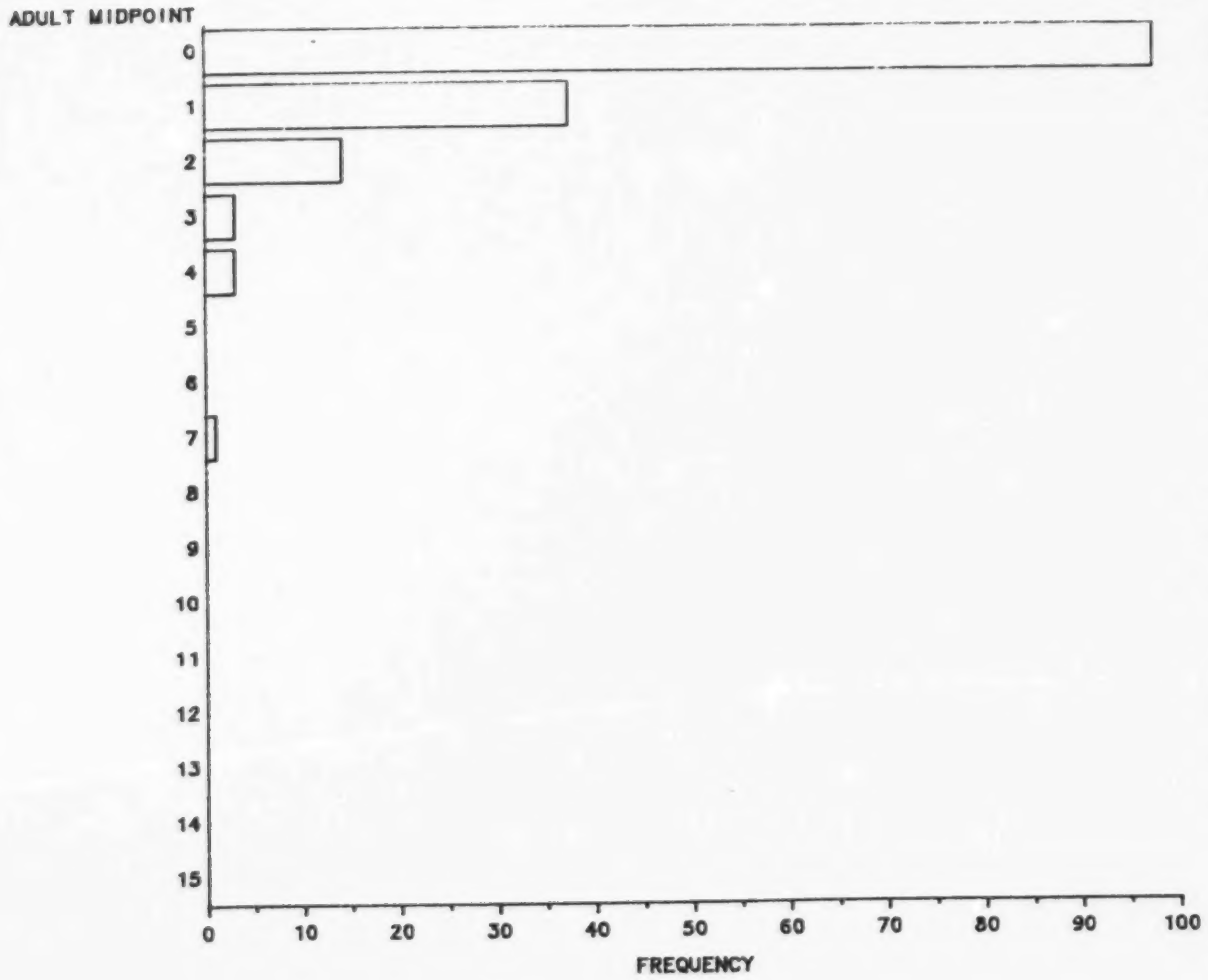
FREQUENCY HISTOGRAM OF CATCH/SET FOR JACK CHINOOK



JACK MIDPOINT	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0	141	141	90.97	90.97
1	10	151	6.45	97.42
2	3	154	1.94	99.35
3	1	155	0.65	100.00
4	0	155	0.00	100.00
5	0	155	0.00	100.00
6	0	155	0.00	100.00
7	0	155	0.00	100.00
8	0	155	0.00	100.00
9	0	155	0.00	100.00
10	0	155	0.00	100.00
11	0	155	0.00	100.00
12	0	155	0.00	100.00
13	0	155	0.00	100.00
14	0	155	0.00	100.00
15	0	155	0.00	100.00

Fig. 10. Frequency histogram of adult chinook catch per set in Juan de Fuca Strait.

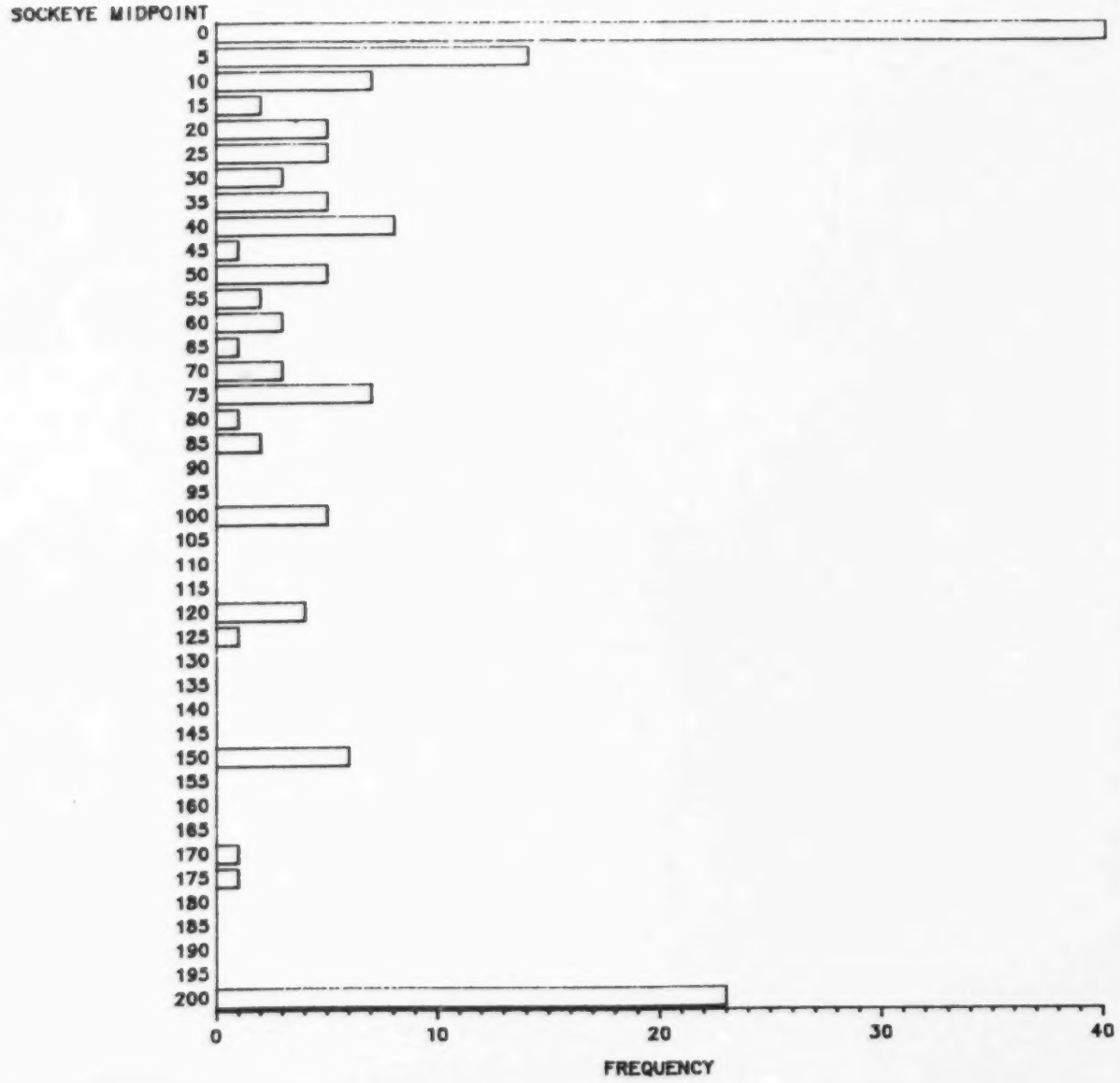
FREQUENCY HISTOGRAM OF CATCH/SET FOR ADULT CHINOOK



FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
97	97	62.58	62.58
37	134	23.87	86.45
14	148	9.03	95.48
3	151	1.94	97.42
3	154	1.94	99.35
0	154	0.00	99.35
0	154	0.00	99.35
1	155	0.65	100.00
0	155	0.00	100.00
0	155	0.00	100.00
0	155	0.00	100.00
0	155	0.00	100.00
0	155	0.00	100.00
0	155	0.00	100.00
0	155	0.00	100.00
0	155	0.00	100.00

Fig. 11. Frequency histogram of sockeye catch per set in Juan de Fuca Strait.

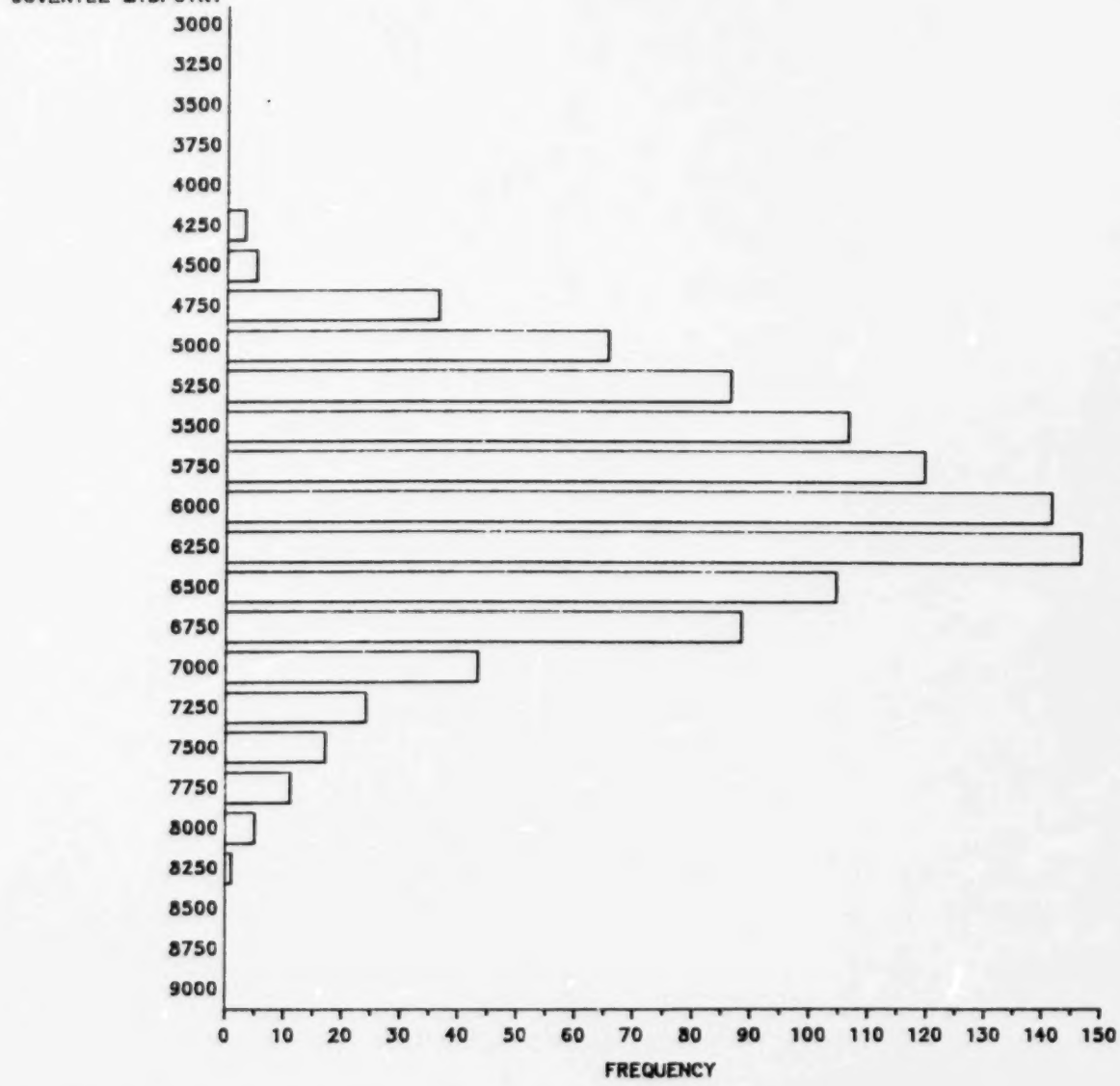
FREQUENCY HISTOGRAM OF CATCH/SET FOR SOCKEYE



SOCKEYE MIDPOINT	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0	40	40	25.81	25.81
5	14	54	9.03	34.84
10	7	61	4.52	39.35
15	2	63	1.29	40.65
20	5	68	3.23	43.87
25	5	73	3.23	47.10
30	3	76	1.94	49.03
35	5	81	3.23	52.26
40	8	89	5.16	57.42
45	1	90	0.65	58.06
50	5	95	3.23	61.29
55	2	97	1.29	62.58
60	3	100	1.94	64.52
65	1	101	0.65	65.16
70	3	104	1.94	67.10
75	7	111	4.52	71.61
80	1	112	0.65	72.26
85	2	114	1.29	73.55
90	0	114	0.00	73.55
95	0	114	0.00	73.55
100	5	119	3.23	76.77
105	0	119	0.00	76.77
110	0	119	0.00	76.77
115	0	119	0.00	76.77
120	4	123	2.58	79.35
125	1	124	0.65	80.00
130	0	124	0.00	80.00
135	0	124	0.00	80.00
140	0	124	0.00	80.00
145	0	124	0.00	80.00
150	6	130	3.87	83.87
155	0	130	0.00	83.87
160	0	130	0.00	83.87
165	0	130	0.00	83.87
170	1	131	0.65	84.52
175	1	132	0.65	85.16
180	0	132	0.00	85.16
185	0	132	0.00	85.16
190	0	132	0.00	85.16
195	0	132	0.00	85.16
200	23	155	14.84	100.00

Fig. 12. Histogram of bootstrap estimates of juvenile chinook catch in Johnstone Strait.

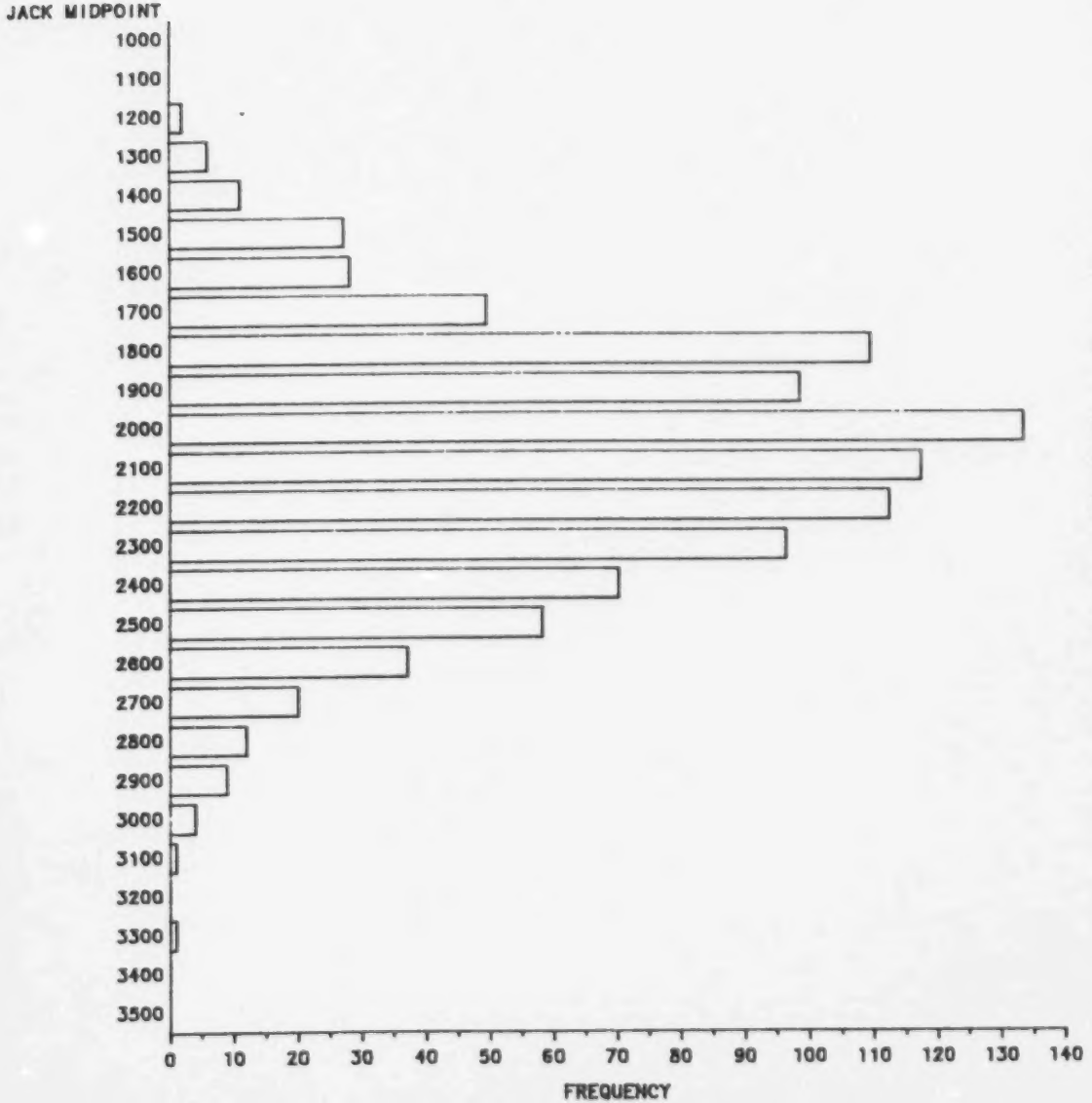
HISTOGRAM OF BOOTSTRAP ESTIMATES OF JUVENILE CHINOOK CATCH



	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
3000	0	0	0.0	0
3250	0	0	0.0	0
3500	0	0	0.0	0
3750	0	0	0.0	0
4000	0	0	0.0	0
4250	3	3	0.3	0
4500	5	8	0.5	1
4750	36	44	3.6	4
5000	65	109	6.5	11
5250	86	195	8.6	20
5500	106	301	10.6	30
5750	119	420	11.9	42
6000	141	561	14.1	56
6250	146	707	14.6	71
6500	104	811	10.4	81
6750	88	899	8.8	90
7000	43	942	4.3	94
7250	24	966	2.4	97
7500	17	983	1.7	98
7750	11	994	1.1	99
8000	5	999	0.5	100
8250	1	1000	0.1	100
8500	0	1000	0.0	100
8750	0	1000	0.0	100
9000	0	1000	0.0	100

Fig. 13. Histogram of bootstrap estimates of jack chinook catch in Johnstone Strait.

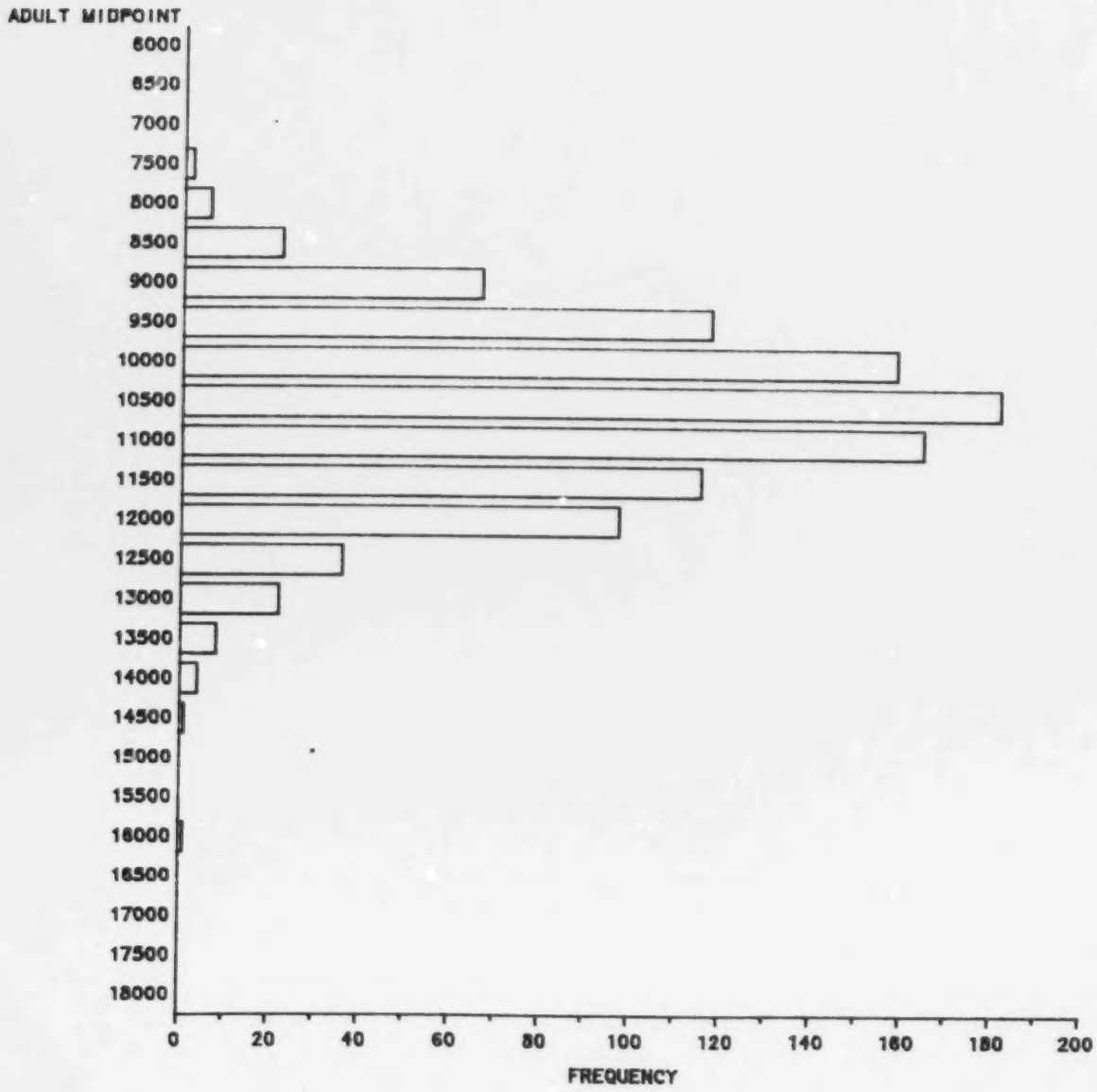
HISTOGRAM OF BOOTSTRAP ESTIMATES OF JACK CHINOOK CATCH



FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0	0	0.0	0
0	0	0.0	0
2	2	0.2	0
6	8	0.6	1
11	19	1.1	2
27	46	2.7	5
28	74	2.8	7
49	123	4.9	12
109	232	10.9	23
98	330	9.8	33
133	463	13.3	46
117	580	11.7	58
112	692	11.2	69
96	788	9.6	79
70	858	7.0	86
58	916	5.8	92
37	953	3.7	95
20	973	2.0	97
12	985	1.2	99
9	994	0.9	99
4	998	0.4	100
1	999	0.1	100
0	999	0.0	100
1	1000	0.1	100
0	1000	0.0	100
0	1000	0.0	100

Fig. 14. Histogram of bootstrap estimates of adult chinook catch in Johnstone Strait.

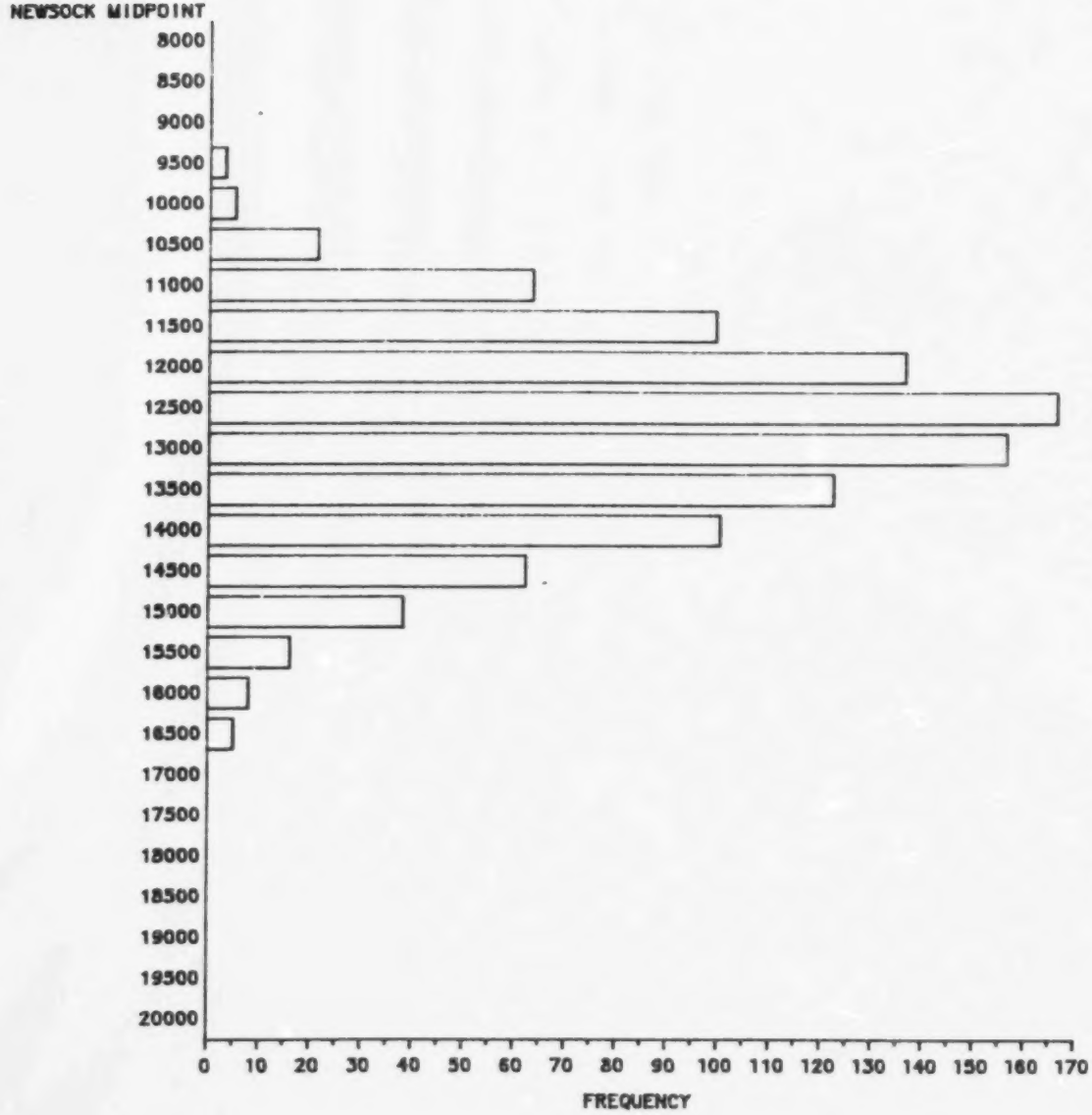
HISTOGRAM OF BOOTSTRAP ESTIMATES OF ADULT CHINOOK CATCH



FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0	0	0.0	0
0	0	0.0	0
0	0	0.0	0
2	2	0.2	0
6	8	0.6	1
22	30	2.2	3
66	96	6.6	10
117	213	11.7	21
158	371	15.8	37
181	552	18.1	55
164	716	16.4	72
115	831	11.5	83
97	928	9.7	93
36	964	3.6	96
22	986	2.2	99
8	994	0.8	99
4	998	0.4	100
1	999	0.1	100
0	999	0.0	100
0	999	0.0	100
1	1000	0.1	100
0	1000	0.0	100
0	1000	0.0	100
0	1000	0.0	100
0	1000	0.0	100

Fig. 15. Histogram of bootstrap estimates of sockeye catch in Johnstone Strait.

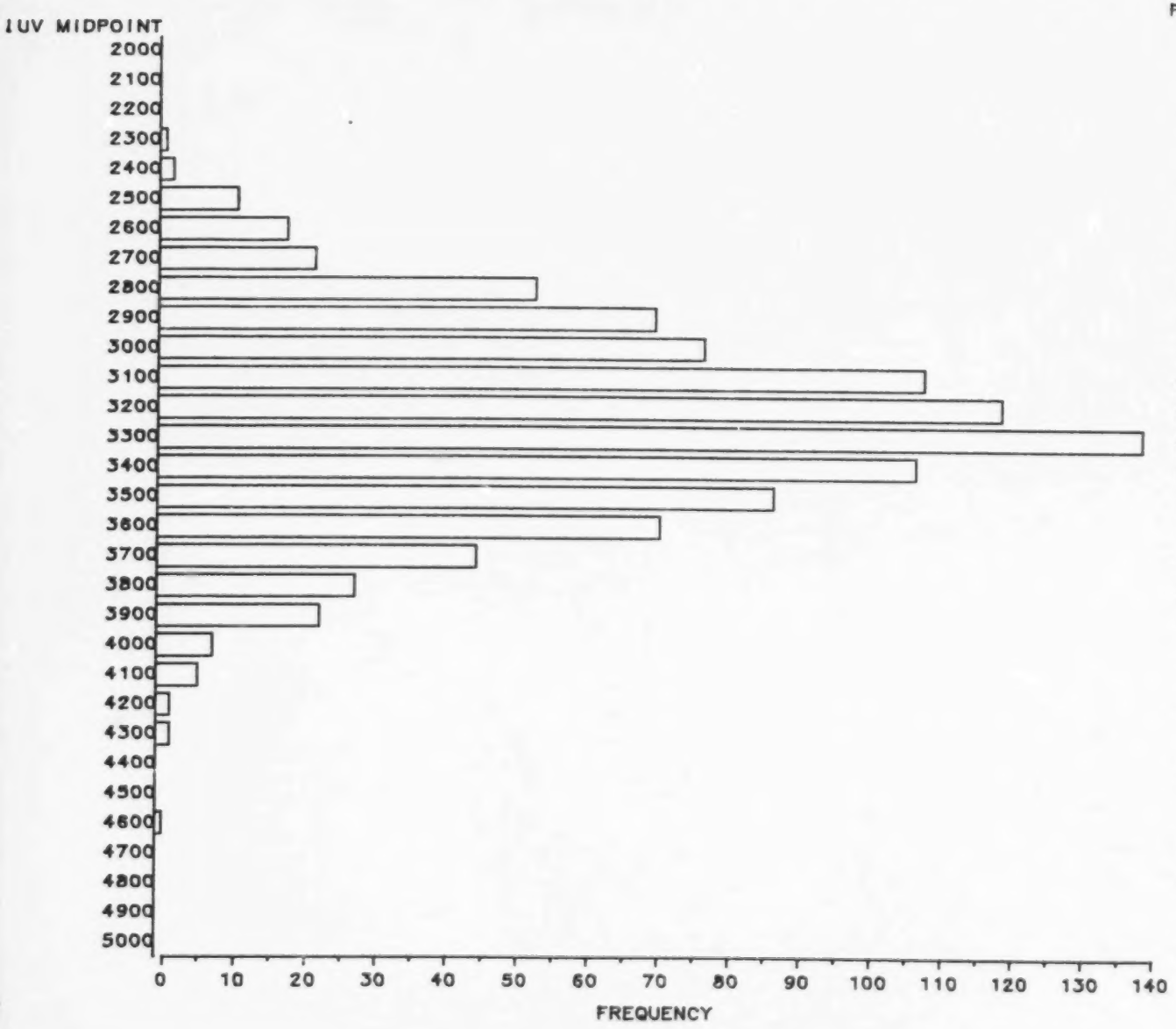
HISTOGRAM OF BOOTSTRAP ESTIMATES OF SOCKEYE CATCH



NEWSOCK MIDPOINT	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
8000	0	0	0.0	0
8500	0	0	0.0	0
9000	0	0	0.0	0
9500	3	3	0.3	0
10000	5	8	0.5	1
10500	21	29	2.1	3
11000	63	92	6.3	9
11500	99	191	9.9	19
12000	136	327	13.6	33
12500	166	493	16.6	49
13000	156	649	15.6	65
13500	122	771	12.2	77
14000	100	871	10.0	87
14500	62	933	6.2	93
15000	38	971	3.8	97
15500	16	987	1.6	99
16000	8	995	0.8	100
16500	5	1000	0.5	100
17000	0	1000	0.0	100
17500	0	1000	0.0	100
18000	0	1000	0.0	100
18500	0	1000	0.0	100
19000	0	1000	0.0	100
19500	0	1000	0.0	100
20000	0	1000	0.0	100

Fig. 16. Histogram of bootstrap estimates of juvenile chinook catch in Juan de Fuca Strait.

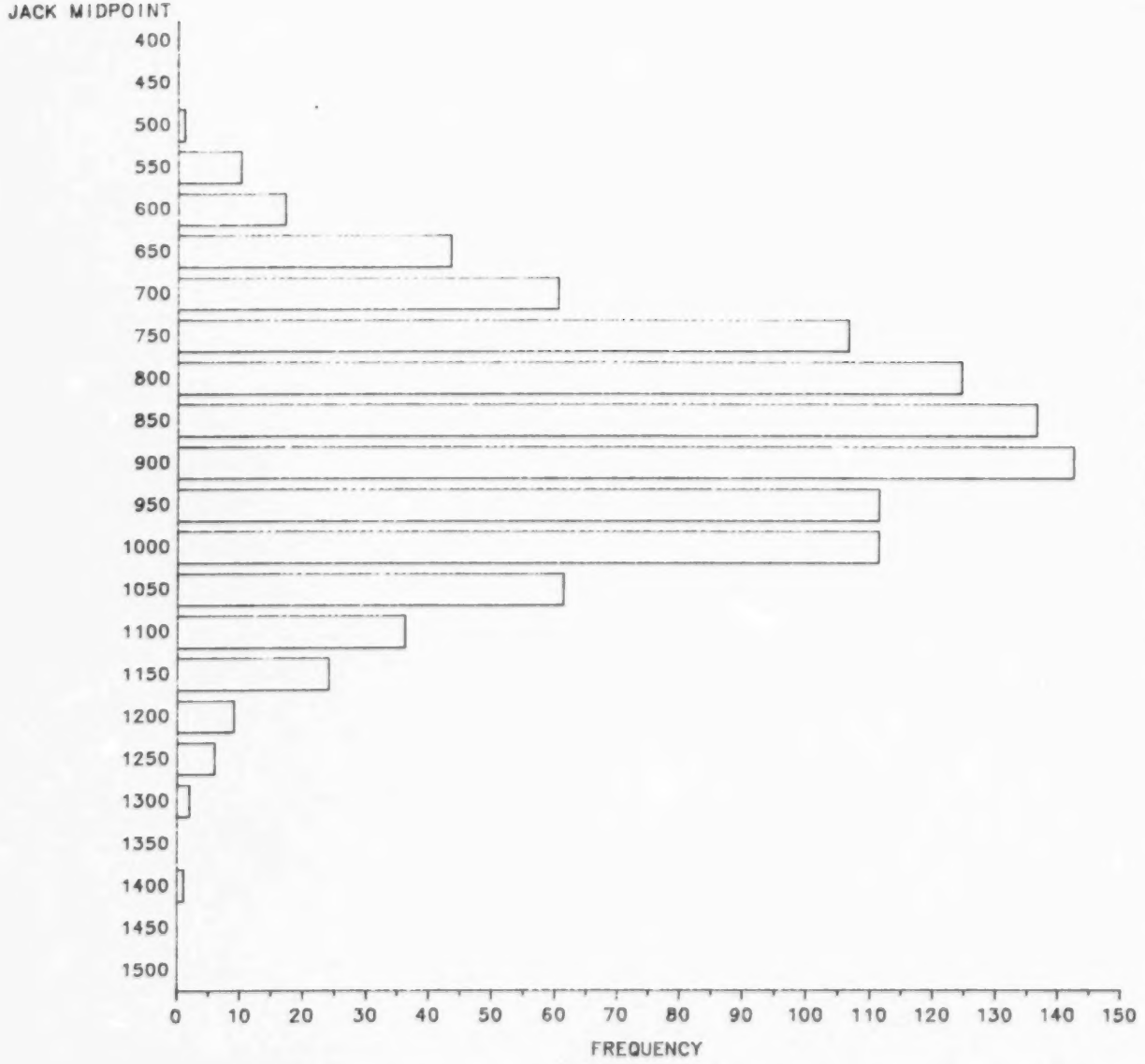
HISTOGRAM OF BOOTSTRAP ESTIMATES OF JUVENILE CHINOOK CATCH



FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0	0	0.0	0
0	0	0.0	0
0	0	0.0	0
1	1	0.1	0
2	3	0.2	0
11	14	1.1	1
18	32	1.8	3
22	54	2.2	5
53	107	5.3	11
70	177	7.0	18
77	254	7.7	25
108	362	10.8	36
119	481	11.9	48
139	620	13.9	62
107	727	10.7	73
87	814	8.7	81
71	885	7.1	89
45	930	4.5	93
28	958	2.8	96
23	981	2.3	98
8	989	0.8	99
6	995	0.6	100
2	997	0.2	100
2	999	0.2	100
0	999	0.0	100
0	999	0.0	100
1	1000	0.1	100
0	1000	0.0	100
0	1000	0.0	100
0	1000	0.0	100
0	1000	0.0	100

- Fig. 17. Histogram of bootstrap estimates of jack chinook catch in Juan de Fuca Strait.

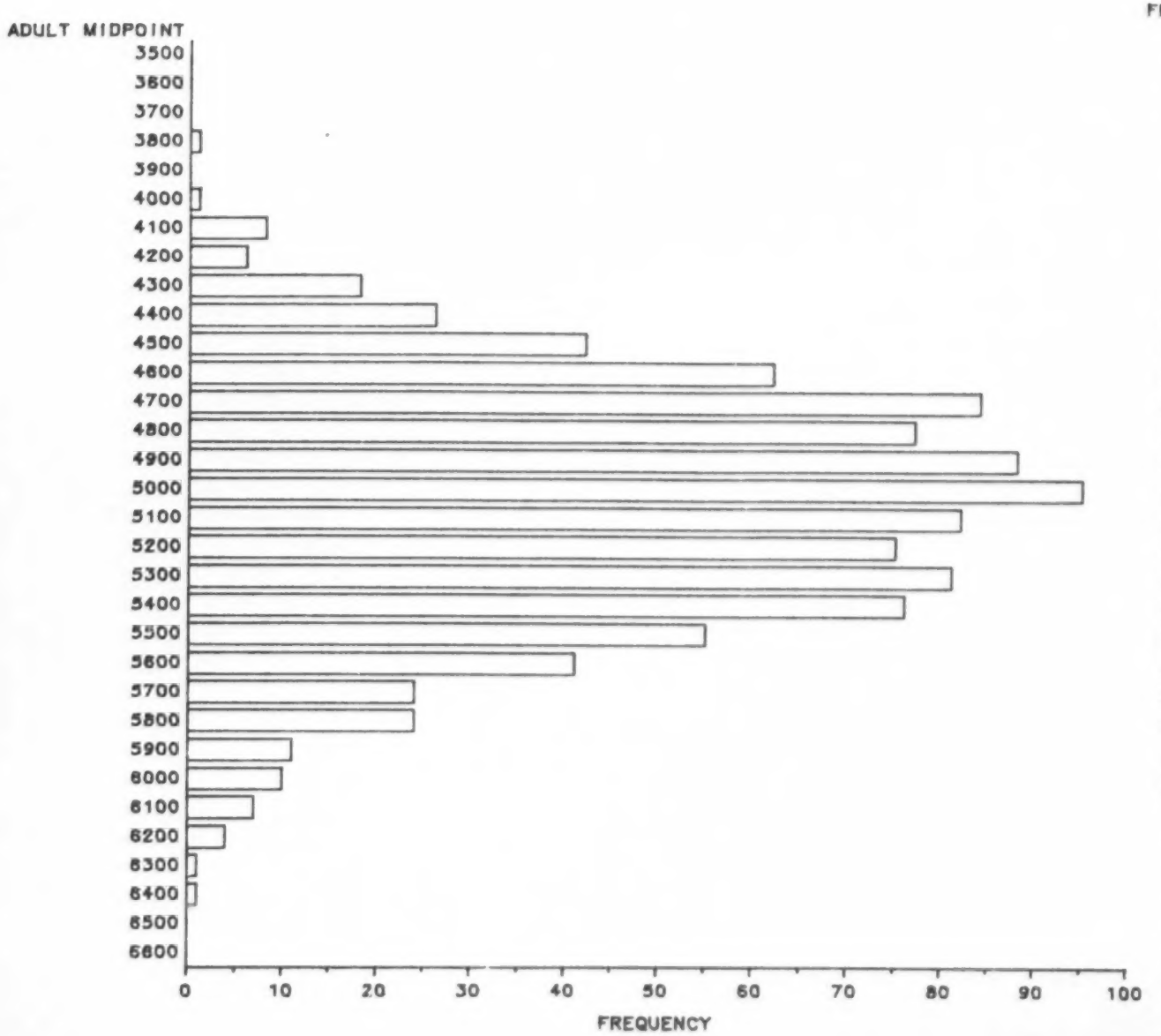
HISTOGRAM OF BOOTSTRAP ESTIMATES OF JACK CHINOOK CATCH



JACK MIDPOINT	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
400	0	0	0.0	0
450	0	0	0.0	0
500	1	1	0.1	0
550	10	11	1.0	1
600	17	28	1.7	3
650	43	71	4.3	7
700	60	131	6.0	13
750	106	237	10.6	24
800	124	361	12.4	36
850	136	497	13.6	50
900	142	639	14.2	64
950	111	750	11.1	75
1000	111	861	11.1	86
1050	61	922	6.1	92
1100	36	958	3.6	96
1150	24	982	2.4	98
1200	9	991	0.9	99
1250	6	997	0.6	100
1300	2	999	0.2	100
1350	0	999	0.0	100
1400	1	1000	0.1	100
1450	0	1000	0.0	100
1500	0	1000	0.0	100

Fig. 18. Histogram of bootstrap estimates of adult chinook catch in Juan de Fuca Strait.

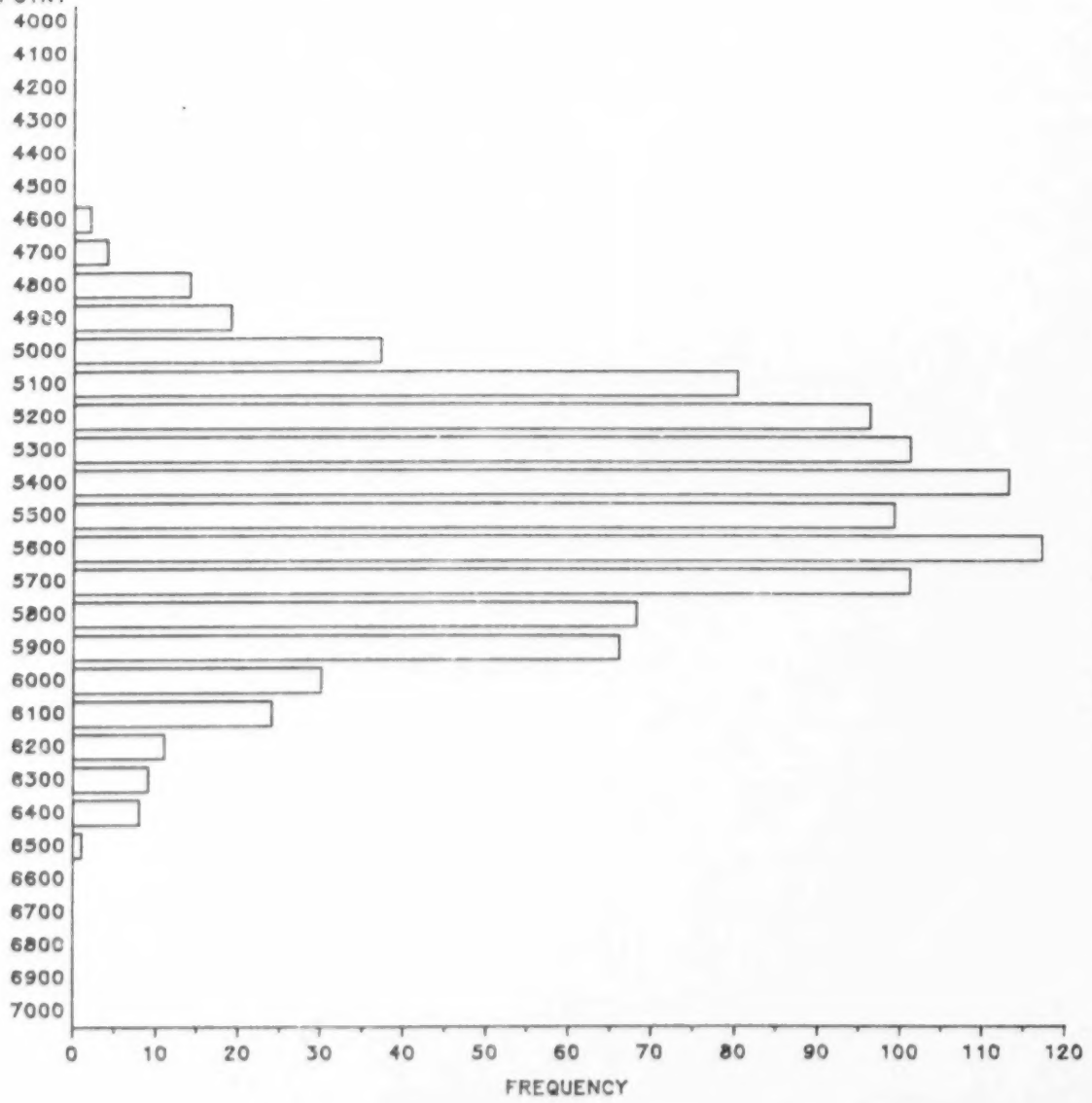
HISTOGRAM OF BOOTSTRAP ESTIMATES OF ADULT CHINOOK CATCH



ADULT MIDPOINT	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
3500	0	0	0.0	0
3600	0	0	0.0	0
3700	0	0	0.0	0
3800	1	1	0.1	0
3900	0	1	0.0	0
4000	1	2	0.1	0
4100	8	10	0.8	1
4200	6	16	0.6	2
4300	18	34	1.8	3
4400	26	60	2.6	6
4500	42	102	4.2	10
4600	62	164	6.2	16
4700	84	248	8.4	25
4800	77	325	7.7	33
4900	88	413	8.8	41
5000	95	508	9.5	51
5100	82	590	8.2	59
5200	75	665	7.5	67
5300	81	746	8.1	75
5400	76	822	7.6	82
5500	55	877	5.5	88
5600	41	918	4.1	92
5700	24	942	2.4	94
5800	24	966	2.4	97
5900	11	977	1.1	98
6000	10	987	1.0	99
6100	7	994	0.7	99
6200	4	998	0.4	100
6300	1	999	0.1	100
6400	1	1000	0.1	100
6500	0	1000	0.0	100
6600	0	1000	0.0	100

Fig. 19. Histogram of bootstrap estimates of sockeye catch in Juan de Fuca Strait.

HISTOGRAM OF BOOTSTRAP ESTIMATES OF SOCKEYE CATCH



NEWSOCK MIDPOINT	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
4000	0	0	0.0	0
4100	0	0	0.0	0
4200	0	0	0.0	0
4300	0	0	0.0	0
4400	0	0	0.0	0
4500	0	0	0.0	0
4600	2	2	0.2	0
4700	4	6	0.4	1
4800	14	20	1.4	2
4900	19	39	1.9	4
5000	37	76	3.7	8
5100	80	156	8.0	16
5200	96	252	9.6	25
5300	101	353	10.1	35
5400	113	466	11.3	47
5500	99	565	9.9	57
5600	117	682	11.7	68
5700	101	783	10.1	78
5800	68	851	6.8	85
5900	66	917	6.6	92
6000	30	947	3.0	95
6100	24	971	2.4	97
6200	11	982	1.1	98
6300	9	991	0.9	99
6400	8	999	0.8	100
6500	1	1000	0.1	100
6600	0	1000	0.0	100
6700	0	1000	0.0	100
6800	0	1000	0.0	100
6900	0	1000	0.0	100
7000	0	1000	0.0	100